Bulletin of the Torrey Botanical Club

Volume 65

FOUNDED BY WILLIAM HENRY LEGGETT 1870

Editor

R. P. Wodehouse

Associate Editors

Bernard O. Dodge

Michael Levine

Henry Allan Gleason

George M. Reed

Tracy Elliot Hazen

John W. Shive

New York 1938

Published for the Club GEORGE BANTA PUBLISHING COMPANY Menasha, Wisconsin

CONTENTS

Young, Pauline. Starch formation in the leucoplasts of Phaseolus	1
LARUE, CARL D., and AVERY, JR., GEORGE S. The development of the	
embryo of Zizania aquatica in the seed and in artificial culture	11
WHITFORD, L. A. A new green alga: Oedocladium Lewisii	23
MARTIN, ROBERT F. Delphinium carolinianum and its allies	27
CAMPBELL, W. A. The cultural characteristics of the species of Fomes	31
HUME, H. HAROLD. The genus Cooperia	79
BERRY, EDWARD W. Additional Miocene plants from Grand Coulee,	
Washington	89
CAMP, W. H. Studies in Ericales III. The genus Leiophyllum	99
Mukz, Philip A. Studies in Onagraceae XI. A revision of the genus	
Gaura	211
Woodson, Jr., Robert E., and Moore, John Adam. The vascular	
	135
	167
McLean, Forman T. A genetic analysis of the inheritance of fragrance	
- O	181
Munz, Philip A. Studies in Onagraceae XI. A revision of the genus	
Gaura2	211
RAO, V. PAKDURANGA. Effect of artificial wind on growth and trans-	
	229
	233
ROBBINS, WILLIAM J. Thiamin and growth of species of Phytophthora 2	267
	277
Drouet, Francis. Notes on Myxophyceae, I-IV	285
Bold, Harold C. Notes on Maryland algae	293
	303
MAXON, WILLIAM R., and MORTON, C. V. The American species of	
	47
Buell, Helen Foot. The taxonomy of a community of blue-green	
algae in a Minnesota pond	77
CLOVER, ELZADA U. The Cactaceae of southern Utah	97
RAO, V. PANDURANGA. Response of sorghum to high and low soil mois-	
ture 4	13
Murphy, James. Raymond H. Torrey 4	33
KARLING, J. S. A large species of Rhizophidium from cooked beef 4.	39
	53
LUNDELL, C. L. Studies in the American Celastraceae I. New species of	
Microtropis, Wimmeria and Zinowiewia 4	63

Brandwein, Paul F. The emergence of smut-inoculated oat seedlings	H H
through cond and loam soil	77
Wells B W and Shunk, I. V. Salt spray: an important factor in	0.5
Target and analogy	85
Company Town H. Spiral systems in the vascular plants	07
FOSTER ADRIANCE S. Structure and growth of the shoot apex in Ginkgo	- 24
7.7.7	531
Course United V Some new and interesting late tertiary plants from	
Custom Creek Idaho-Oregon boundary	557
CLOVER ELZADA U. New species of cacti from Guatemala, Mexico and	- / -
M	565
Garage H. A. Notes on American melastomes, including nine new	~ 7 1
	571
Date CHARLES R Some Psilophytales from the Hamilton group in	500
Novy Vork	599
To D. Notes on plants of the Pacific Islands. 1	607
T S Studies on Rhizophidium. II. Knizophidium laterate	615
The Description of the Uredinales, the genus Chacoma	625
E SIDNEY O The cytology of Cuscuta	631
Manager W A New Florida Polypores	647
T. 1. American Rotanical Literature	
70, 123, 198, 250, 354, 421, 455, 361,	662
Index to Volume 65	675
THUCK TO A CAMPAGE TO THE PROPERTY OF THE PROP	

Dates of publication

No. 1, for January, pages 1-78, issued January 6, 1938

No. 2, for February, pages 79-134, issued February 1, 1938.

No. 3, for March, pages 135-209, issued March 1, 1938

No. 4, for April, pages 211-265, issued April 1, 1938

No. 5, for May, pages 267-345, issued May 18, 1938

No. 6, for June, pages 347-432, issued June 20, 1938

No. 7, for October, pages 433-505, issued October 1, 1938

No. 8, for November, pages 507-597, issued November 1, 1938

No. 9, for December, pages 599-692, issued January 5, 1939

Errata

P. 518, Fig. 8. For 18-17-31-1 read 18-17-35-1 Pp. 511, 512, 520. For Fabonacci read Fibonacci

Starch formation in the leucoplasts of Phaseolus vulgaris

PAULINE YOUNG

(WITH PLATE 1)

It is generally assumed that, in the transformation of soluble carbohydrate to insoluble starch in the plastid, intermediate products are formed. In the absence of definite knowledge of the chemical constitution of such compounds it is quite commonly assumed that we are dealing here with a reversible reaction and that clues to the "Aufbau" of starch will be found in the products of its hydrolysis.

Mikosch (1885) called attention to a zone surrounding the young starch grain in the leucoplast which he believed was the "mother substance" from which new starch was formed. Salter (1898) also described such an area, which he interprets as a zone of starch of greater density than that of rest of the grain.

Denniston (1905) observed a distinct orange-staining layer around growing starch grains of Canna stained in Flemming's triple stain. He regards this layer as being composed of a transitional material. He observes that a new layer of starch first appears as a narrow violet-stained crescent in the midst of the orange zone. This isolated violet zone gradually widens in the direction of the latest formed layer of starch until the enclosed part of the orange zone is completely replaced with violet-staining starch. The latest part of the layer to be deposited is pale violet as contrasted with the deep violet first-formed part of the lamella. Denniston suggests that the formation of the new layer may be due to the condensation of carbohydrate material from smaller carbohydrate-like molecules, brought about by the abstraction of water, or other similar chemical change. The suggestion is also made that the orange zone is already a carbohydrate material which is later transformed into starch. The latter suggestion is regarded as being the most probable.

Although not attempting to explain the cause of stratification, Denniston regards the phenomenon as being due to the layers of varying densities in the starch grain. Those layers retaining the most stain are regarded as the most dense on the assumption that the stain is removed with less difficulty from the less dense layers.

The material for this study was fixed in weak chrom-acetic mixture, in Benda's fixative and in Merkel's fixative, the time being from 24 to 48 hours. The cotyledons of the young seeds were used in all cases. When very small, the entire cotyledon was fixed, after dissecting it out of the

seed coat. Larger cotyledons were cut into small pieces before fixation. In the case of the very youngest cotyledons, portions of the entire pod were fixed. Portions of living cotyledons were also used with vital stains and with the iodine test and Fehling's reaction.

Most of the sections were stained with Flemming's triple stain. With this stain the nucleoli and certain bodies, probably protein in nature, stain red; the body of the plastids stains deep orange, the cytoplasm a distinctly paler orange and the starch grains violet. Not all the structures that stain violet are necessarily starch, but any substances within the plastid retaining the violet stain is quite obviously starch. This has been proved conclusively by tests made with iodine and with the polariscope. With Heidenhain's iron haematoxylin, with the fixatives used, the cytoplasm stains gray, the plastids blackish and the starch remains unstained.

The so-called vital stains, methylene blue, neutral red and Janus green, were used in an attempt to determine the nature and the origin of the leucoplasts. Other sections were treated with a modified Millon's solution (the Sachs test for dextrin) with the hope of obtaining some light on the composition of the vacuolate centers of the smaller plastids.

In the living cells of very young cotyledons there are minute spherical bodies in the cytoplasm adjacent to the cell membrane. With neutral red solution (1–500) the bodies stain a dark red in contrast with the paler red of the cytoplasm. In these same cells slightly larger bodies have the appearance of being hollow, showing a dark red peripheral region and light central areas, with the neutral red. This appearance is probably to be interpreted as showing a dense protoplasmic shell surrounding either a watery protoplasmic center or a non-protoplasmic vacuole. With Janus green and methylene blue the smaller bodies stain respectively green and blue, and the larger ones show respectively green and blue borders with light centers.

When tested with iodine, the lighter vacuole-like centers of the bodies in question show no positive color reaction. The iodine test also gives negative results with cells which have been treated with a chloral hydrate solution in order to swell any starch inclusions in the central area. Examination of this central region with the polariscope shows no figures characteristic of starch. Thus the above results indicate that there is no starch in these central regions at this stage in the development of these bodies.

With Fehling's solution the lighter central areas show a light brick red color which disappears upon being placed in absolute alcohol. The old Sachs test for dextrin was a brick red color reaction with Fehling's solution which was not removed with absolute alcohol. This test has been

discredited (Zimmerman, 1893) since pure dextrin cannot reduce Fehling's solution.

A brick red color with Fehling's solution, even though not permanent, is very significant and indicates that an incipient reduction of the copper has taken place due, no doubt, to the presence of some aldehyde carbohydrate.

In the fixed and sectioned material of these youngest cotyledons, the cytoplasm of the peripheral layer contains minute rounded bodies which lie right at the limit of clear vision, probably $\frac{1}{4}$ micron or less. These are stained orange in Flemming's triple stain (fig. 2a). These orange-staining bodies occupy the same position in the cell, are similar in size to those bodies which stain red with neutral red in unfixed material. They are undoubtedly identical with them. Other bodies slightly larger, $\frac{1}{2}$ micron in diameter, in fixed material, show minutely granular, orange-stained peripheral layers with paler central regions that contain no starch and show no traces of granularity (fig. 2b). These are comparable in size and general appearance to the bodies showing thick dark red borders and light centers when stained with neutral red in fresh material. This pale orange central area is the same as the central region which reacts light brick red with Fehling's solution in the slightly larger bodies of the fresh cells.

The cells of the fresh cotyledons a few days older than those referred to above contain, in addition to the previously discussed rounded bodies, others noticeably larger. These bodies when stained with neutral red show dark red peripheries and have the lighter centers somewhat larger than those already described. These appear homogeneous throughout, but when tested with iodine there is to be seen in its central part a definitely marked area which gives the characteristic reaction for starch. Around this minute blue-stained starch grain there is a zone of the central area which shows no reaction for starch. These larger bodies with small starch grains in their lighter central areas are very similar to those smaller ones, the central areas of which show no starch. The central portion of the larger bodies is, however, often eccentric so that the orange-staining peripheral regions are thicker at one end.

In fixed material of the same age, these earliest starch grains retain none of the violet of Flemming's triple stain (fig. 3a). With the polariscope they show the figures characteristic of starch. With Flemming's triple stain considerable care must be taken to keep the violet dye in the large grains even, so it is not surprising that in these very smallest grains the stain is lost.

It seems clear that the deep orange-staining zones surrounding the

small starch grains are to be regarded as leucoplasts. These are similar to and occupy the same position with relation to the central areas as those of the smaller bodies with central zones containing no starch. It may therefore be concluded that the latter are also plastids. These can be traced back through an unbroken series to those small bodies which lack the lighter central zone and which are therefore also plastids or primordia of plastids (fig. 4b). These smaller plastids are very minute and numerous in the young cells and it is impossible to make any definite statement as to their origin. In no case, however, were they observed to be dividing, so that the assumption that they arise de novo from the cytoplasm seems justified.

In sections from older cotyledons, stained with Flemming's triple stain, the stages in the development of the starch grain may be observed. As has already been made clear, there appears in the smaller, deep orange-staining plastids, a central area of a texture and staining reaction different from the periphery (fig. 5a) which shows no indication of starch with the polariscope. Slightly larger plastids (fig. 5b–g) show very minute crosses with the polariscope; they do not occupy the whole of the central area. In the centers of still larger plastids these small starch grains now stain readily with the crystal violet and they do not fill entirely this central area but are surrounded by a zone staining light orange (fig. 5h). The starch grain thus develops in the midst of this material which gives the temporary reaction with Fehling's solution.

In the formation of a second layer of starch around this first minute grain there is deposited around it a paler violet-staining layer (fig. 5i). The orange-staining layer between the plastid and the starch grain tends to maintain its original thickness although, according to Denniston's observations on Canna, it is very probable that a part of it is utilized in the formation of the new layer. In a few cases, in the larger starch grains, a dark layer surrounds a paler center (fig. 6a). It may be that these are transverse sections of elongated starch grains cut near the end, since none of the smaller ones were seen with light central layers surrounded by a darker layer.

The growing starch grain (fig. 6c) is composed of distinct, alternating layers of dark and light violet-staining material with a light orange-staining layer, similar to that designated by Denniston (1905) as the transitional zone lying between the starch grain and the plastid material. There is no gradual transition from the light staining starch to the darker staining in each lamella as in the starch grain of Canna and other similar starch grains. The number of layers is not as great as in the Canna or potato starch grain, usually not exceeding five or six.

In the bean starch grain new layers are formed at the outer extremity

of the latest formed old layer of the starch grain. In case the latest formed layer stains pale violet, there arises at its outer extremity a layer staining distinctly darker (fig. 6b-c). This layer widens gradually and when it has grown to the average thickness there is formed around it another layer staining pale violet. Thus the new layers are growing into the orange-staining zone from the latest formed layer of starch. It seems obvious that with actively growing starch grains there is an area within the plastid which is not starch but which has a chemical composition intermediate between the soluble carbohydrates and starch.

With the older starch grains the deep orange-staining plastids which surround them are often thicker at one end so as to form a cap-like structure (fig. 6b-c). In such starch grains the developing layer of starch arises earliest on that end of the grain where the cap-like part of the leucoplast is found and gradually grows around the grain forming a layer approximately uniform in thickness.

Some of the starch grains which are apparently not growing do not have the light orange zone so that the starch is in direct contact with the granular plastid (fig. 6d). It seems reasonable to assume that these plastids are temporarily inactive.

DISCUSSION

It cannot be said that the question of the origin of plastids in the vascular plants has ever been fully settled. Schimper's view of the continuity of the plastid through the life cycle of the plant, while somewhat discredited in the vascular plants, has not been disproved beyond all possibility of doubt. On the other hand the origin of the plastid de novo, from undifferentiated cytoplasm has not been finally proved. Recently Miss Stone (1932) has presented evidence of the presence of chlorophyll in undifferentiated cytoplasm of cells of young leaves of potato and condensation of this chlorophyll-bearing cytoplasm to form chloroplasts is described. It seems surprising that such obvious condensations of cytoplasm to form chloroplasts as Miss Stone describes could have been overlooked so long. Her account of this phenomenon will undoubtedly stimulate new work in this phase of plastid formation. More recently Kiyohara (1935) has described plastids in the eggs and pollen tubes of certain angiosperms and is of the opinion that his findings present positive proof of Schimper's view.

In *Phaseolus vulgaris* undoubted leucoplasts containing very small starch grains may be traced through an unbroken series to minute structures which are obviously also plastids. Since these are very small and very numerous it is impossible to determine their origin, but there is no evi-

dence of their having arisen from similar bodies by division. Although the exact origin has not been determined, the most reasonable conclusion seems to be that they have arisen de novo from the cytoplasm. It seems very probable that plastids may be formed in a different manner in the different plant groups and in different phases in the life cycle of the same group. For example, multiplication by fission is easily followed throughout the period of growth of many algae, while in the higher plants it is difficult to find stages of plastid fission except in fully developed chloroplasts.

As has already been observed by Mikosch (1885) and Salter (1898), the very young plastid becomes differentiated into a peripheral layer and a central vacuole-like layer previous to the beginning of starch formation. In *Phaseolus* the peripheral layer is noticeably granular and stains quite strongly with orange G. The layer is regarded as the active or protoplasmic part of the leucoplast. The central region is homogeneous and lacking in granularity and, in *Phaseolus*, stains faintly with orange G. Although this central area differs from the peripheral layer in texture and refractivity, as well as staining reaction, it is not impossible that it is protoplasmic and may be regarded as a part of the leucoplast which either is being transformed or is engaged in transforming some carbohydrate into starch.

The color reaction of the central area of the leucoplast with Fehling's solution is of considerable significance and points to the presence of an appreciable amount of an aldehyde carbohydrate. That the reaction is not permanent may indicate that glucose or other actively reducing carbohydrate is not present. The appearance of the young starch grain, following so closely upon the appearance of this vacuolar stage, suggests very strongly that polysaccharide molecules of considerable size are present in this central area.

The difference between the deposition of starch in *Phaseolus vulgaris* and in *Canna* is of considerable interest. In the former, new layers are apparently formed by a transformation of that part of the orange-staining zone adjacent to the latest formed old layer of the starch grain and growth is away from the center. On the other hand, according to Denniston (1905), new layers in the *Canna* starch grain appear first as crescent-shaped masses in the midst of the thick part of the eccentric orange-staining zone, and gradually extended toward the last formed layer until it is reached. The layers in the starch grains in *Phaseolus* stain alternatingly dark and light with iodine or gentian violet, with no gradual transition of the one into the other. In *Canna* there is a gradual transition in each layer from dark violet on the outside to light violet on the inside of the layer.

Starch grains of certain other plants, as some of the cereal grains, show no lamellae at all. Zwikker (1921) has attempted to demonstrate that the presence or absence of lamellae is correlated with an excess or deficiency of certain electrolytes. Wheat starch, showing no distinct lamellae, normally contains an excess of calcium ions, while potato starch with its conspicuous lamellae contains an excess of potassium ions.

This work of Zwikker is but one of many on the chemistry of the starch grain from a colloid-chemical view point. From Samec's (1927) exhaustive review of the subject it will be seen that it is one of great complexity. No substantial agreement has been reached as to the relation of the carbohydrate starch to the mineral constituents of the starch grain. The data accumulated, however, point clearly to a relationship between such elements as phosphorus, silicon, potassium and calcium and the characteristic reaction of different starch grains to malt extract and other hydrolytic agents, the formation of colloidal pastes and probably the characteristics of their lamella formation. The difference in the lamellation in the starch grains of *Phaseolus* and *Canna* may very well be connected with characteristic differences in the mineral content of the grains.

The starch grain is clearly not a simple structure made up of the carbohydrate starch with the mineral constituents adhering in an indefinite manner to its exterior, but a close association exists between these two types of components. The mineral compounds may lie between the micellae which make up the composite starch crystal or may even be in loose chemical combination with them.

SUMMARY

- 1. Very young leucoplasts contain vacuole-like central areas which do not react as starch but which show a distinct brown-red color reaction with Fehling's solution, which color is removed by absolute alcohol. This reaction must indicate the presence of an aldehyde carbohydrate.
- 2. The young starch grains originate in the vacuole-like central areas of these plastids.
- 3. Surrounding the growing starch grain there is a persistent zone having similar color reactions to the vacuole-like area.
- 4. New layers of starch are formed at the outer extremity of the last formed old starch grain and grow outward.

This work was completed at the botanical laboratories of the University of Texas. The writer wishes to express her sincere appreciation to Professor Frederick McAllister for his assistance and criticisms.

Literature cited

Denniston, R. H. 1905. The growth and organization of the starch grain. Trans. Wis. Acad. Sci. 15: 664-708. pl. 38-40.

Kiyohara, Kogane 1935. Zur Schimper-Meyerschen Theorie der Vermehrung der Chloroplasten. Journal of the Faculty of Science, Imp. Univ. Tokyo Sec. 3, Bot. 4: 399-465. pl. 1-7.

Mikosch, Carl 1885. Über die Entstehung der Chlorophyll-körner. Sitzber. Weiner Akad. 92: 168-197. two plates.

Salter, J. H. 1898. Zur näheren Kenntniss der Stärke-körner. Jahrb. wiss. Bot. 32: 117-166. pl. 1-2.

Samec, M. 1927. Kolloidchemie der Stärke. Dresden and Leipzig.

Stone, Winona E. 1932. The origin, development, and increase of chloroplasts in the potato. Jour. Ag. Res. 45: 422-435. pl. 1-10. 6 text figs.

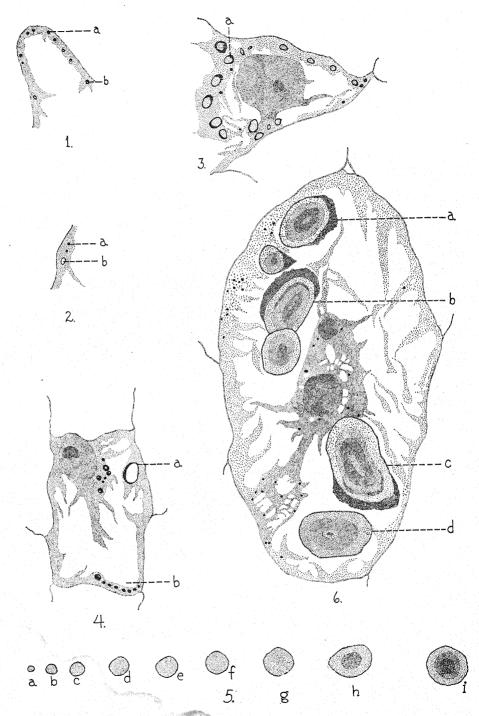
Zimmerman, A. 1893. Botanical microtechnique. Trans. from Ger. by Humphrey. Zwikker, J. J. L. 1921. L'action des enzymes amolytiques sur les grains d'amidon naturels et la structure colloidale de l'amidon. Rec. trav. bot. neerl. 18:

Explanation of plate 1

All drawings were made with the aid of a camera lucida the magnification being 1750 times.

- Fig. 1. Portion of a cell from a very young cotyledon stained with Heidenhain's iron haematoxylin showing the minute plastids (a) and the slightly larger plastids (b) with vacuole-like centers containing no starch.
- Fig. 2. Portion of a cell from a very young cotyledon stained in Flemming's triple stain showing minute orange-stained plastids (a) and slightly larger orange-stained plastids with vacuole-like centers containing no starch.
- Fig. 3. Portion of a cell from a cotyledon a few days older, stained with Flemming's triple stain, showing in addition to the smaller plastids, those which contain small starch grains which have not retained the violet of the stain.
- Fig. 4. Entire cell from an older cotyledon stained with Heidenhain's stain, showing various stages in the development of the plastids—the larger ones containing small starch grains.
- Fig. 5. Successive stages in the development of young starch grains, from an old cotyledon, stained with Flemming's triple stain.
 - a. Small plastid with vacuole-like center containing no starch.
 - b-g. Plastids containing small starch grains that do not retain the violet stain.
- h. Plastid showing violet-staining young starch grain surrounded by the light orange zone.
- i. Plastid showing a young, dark violet starch grain with a pale violet layer surrounded by a pale orange zone.
- Fig. 6. Entire cell from an old cotyledon showing starch grains in various stages of development. Stained with Flemming's stain.







The development of the embryo of Zizania aquatica in the seed and in artificial culture

CARL D. LARUE AND GEORGE S. AVERY, JR.

(WITH EIGHT FIGURES)

The normal embryogeny of certain grasses is well known: Avena fatua L. (Cannon, 1900), Poa annua L. (Souèges, 1924) and Zea mays L. (Randolph, 1936). The embryos of these three species, upon their development into seedlings are representative of two of the three morphological types distinguished by Van Tieghem (1897). It has been shown since that they are all fundamentally one type, appearing differently upon development because of the difference in location of the meristematic region in the first internode (Avery, 1930). If the species indicated above may be considered typical of the family, the general course of embryogeny is the same for the approximately 5000 species (Bews, 1929) of grasses. In the structural aspects of its development into a seedling Zizania follows closely that of Avena.

Although the culture of plant embryos in vitro has been demonstrated many times (Hannig, 1904; Dietrich, 1924; Tukey, 1934; etc.), the culture of embryos starting with relatively young stages is of recent date; apparently no comparative studies have been made of embryogeny in vivo and in vitro.

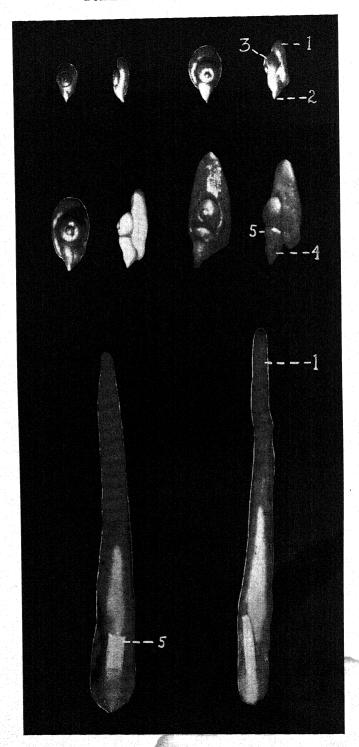
It has been pointed out (LaRue, 1936) that in maize the cotyledon ceases to grow when the embryos are cultured on agar. The question at once arises as to whether embryos in culture continue to develop as "normal" embryos, or, whether their normal growth and form is dependent upon their presence within the tissues of the parent plant.

The embryo of Zizania was chosen for this study because it possesses (1) a cotyledon which changes in the course of its development from a flat circular disc to a markedly linear organ. In the course of this development its width increases only five times, but its length 125 times, i.e., in normal embryogeny it shows marked polarized growth. It possesses (2) an epiblast which undergoes changes similar to those of the cotyledon but lesser in degree. Such changes in the length-width ratio of these two structures are so pronounced that any departure from normal embryogeny may be detected.

Is the growth and form of the cotyledon (and epiblast) inherent in the genotype, or is its development subject to environmental circumstances?

MATERIALS AND METHODS

Embryos were removed from ovaries by dissection under a low-power



binocular microscope. They ranged in stage of development from the smallest which could be removed readily (0.2 mm. in diameter) to fully grown embryos. Aside from the sterilization of all dissecting instruments, etc., no further sterilization was attempted; little difficulty was encountered in removing the embryos aseptically, and placing them on agar media in Petri dishes.

The culture medium used was made up with the salts of White's (1934) solution, two per cent cane sugar and one per cent agar-agar. The yeast extract of White's solution which had been found unnecessary for the growth of maize embryos (LaRue, 1936), was omitted.

For studies on normal embryogeny the embryos were dissected from their ovaries at different stages of development, fixed in formalin acetic alcohol or Nawashin's solution, imbedded in paraffin, etc. The artificially cultured embryos were grown for 5 days in diffuse light or in the dark under ordinary laboratory conditions. They were then fixed and imbedded by the same procedure as that used for the normal embryos; all were cut at a thickness of 6–10 microns and stained with fast green.

The 5-day period for the growth of the embryos was chosen because in that interval of time mature embryos reached the stage at which the shoot burst through the coleoptile thus marking the beginning of their development as seedling plants. The smaller the embryo (upon transfer to agar culture) the longer the time required for it to reach this stage. All but the smallest embryos were grown ultimately to the stage of rupture of the coleoptile, but the significant changes in their development were initiated, at least, within the 5-day period.

OBSERVATIONS

Gross development of normal embryos and embryos in culture. Since our aim was a study of comparative embryogeny in vivo and in vitro, no attempt was made to start with embryos smaller than could be removed readily (0.2 mm.). A study of the early phases of embryogeny in vitro awaits improved techniques; early development seemed less important to this study because the early stages are concerned more with increase in number of cells than with differentiation. We chose to study the period of development in which the embryo acquires its most characteristic features.

In order to determine the relative ages of the embryos used in this study, their normal embryogeny (in the developing seed) was studied in relation to time (table 1).

Fig. 1. Embryos of Zizania aquatica: 0.2mm., 0.3mm., 0.7mm., 0.9mm., 5mm., and 12mm. (under varying magnifications). 1, cotyledon; 2, suspensor; 3, coleoptile; 4, coleorhiza; 5, epiblast.

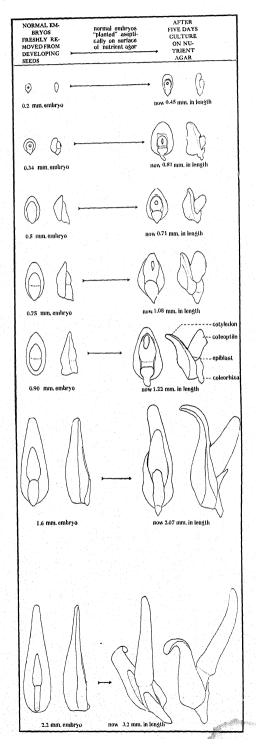


Table 1

Data on growth in length of embryos of

Zizania

DAYS AFTER POLLINATION	LENGTH OF EMBRYOS IN MM.
3	0.1
5	0.15
7	0.35
9	1.0
11	1.5
13	2.25
15	4.0
17	8.0
19	10.0

Upon removal to agar culture, the embryos of all but the smallest sizes grew readily. The mature (embryos 10–12 mm. in length) but "unripe" seeds required no rest period; when planted they would germinate at once. When once "ripened," however, the seeds would not germinate even if the pericarps were cut open, although the embryos if removed and placed on nutrient agar, grew satisfactorily.

A comparison of growth rate in normal embryogeny and cultured embryos is not possible. Total length-growth of an embryo in the seed is much greater than when in culture and presumably the increase in volume is of the same degree. An embryo

Fig. 2. Zizania aquatica; diagrams of normal embryos as removed from ovaries, and of similar embryos after 5 days culture on nutrient agar. Note the development of the coleoptile (and of the coleoptiza in the larger embryos) during the period of growth in culture.

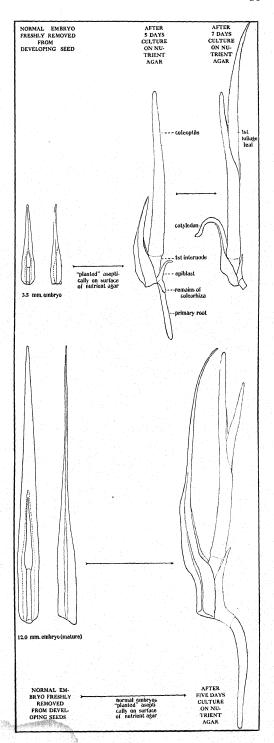
2.2 mm. long (about 13 days after pollination) became 3.2 mm. long after 5 days in culture. If left undisturbed in the seed for this length of time, the same embryo would have increased to 8 mm. in length. But such a comparison obscures the facts; length-growth of the cultured embryos means growth of the coleoptile and first internode, while that of the normal embryo represents increase in length of the cotyledon.

The major differences between the two sets of embryos are differences in form. See figures 1 to 3 for illustrations of this development.

MICROSCOPIC OBSERVATIONS
ON THE DEVELOPMENT OF
THE NORMAL EMBRYOS AND
EMBRYOS IN CULTURE

Embryos 0.2 to 0.35 mm. (figs. 1 and 2) upon removal from ovaries often double their length after 5 days in culture, but undergo no further differentiation. The stem growing point, upper portion of the coleoptile, and the cotyledon are clearly dis-

Fig. 3. Zizania aquatica; continuation of fig. 2. The coleoptile, first internode, and primary root have elongated markedly after 5 days in culture; the cotyledon and the epiblast do not show further development.



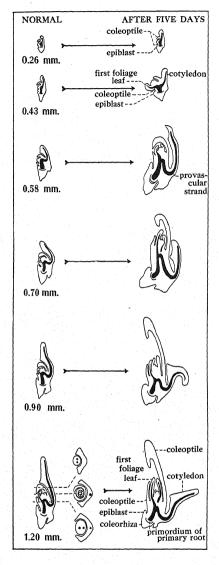


Fig. 4. Zizania aquatica; diagrams of median longisections of normal embryos of various sizes, and of similar embryos after 5 days culture on nutrient agar.

tinguishable (figs. 4 and 6); the provascular strand is barely discernible in the latter. The root primordium, not yet differentiated in normal embryos of this size, fails to differentiate during the five days in culture.

Normal embryos 0.4 mm. or more in length at the time of transfer to agar, underwent the following structural changes in the course of five days in culture (figs. 4, 5 and 7): (1) The cotyledon and epiblast underwent a slight increase in size, but there was no evidence of cell division continuing in these structures after the transfer of the embryos to agar culture.

- (2) The coleoptile in 0.4 to 0.7 mm. embryos increased in size as a result of the enlargement of its cells, but there was no evidence of a continuation of cell division; however, cell division in this structure continued in culture if the embryos were 0.9 mm. or longer at the time of transfer. The "pore" in the more or less conical coleoptile seldom closed in the embryos which were 1.5 mm. or less in length at the time of transfer to agar.
- (3) Either the first foliage leaf or the first internode were the initial structures to undergo marked development when the embryos were transferred to agar; in either structure, there was a long period of cell division after the transfer.

(4) The primary root, although clearly differentiated, is the last structure to undergo discernible change after transfer of the embryos to culture. Its growth is slow in embryos less than about 3.0 mm. in length at the time of transfer.

DISCUSSION

It is clear that when embryos of Zizania were placed on nutrient agar, the cotyledon and epiblast ceased to grow; in contrast, the shoot pri-

mordium (and in older embryos, the primary root) departed from its slow growth and differentiation, and began what was virtually a precocious "germination" or development into the seedling stage (similar to the gross morphological development of maize embryos in culture, (La-Rue, 1936). Zizania is an excellent subject for the study of comparative embryogeny in vivo and in vitro because the mature normal embryo possesses a cotyledon which extends the entire length of the fruit, often extending around the end of the caryopsis and downward on the back side; the epiblast also is unusually long and prominent. In embryos transferred to agar culture both these organs fail to continue their polarized growth. It is obvious that the continued elongation of these organs is a matter of embryonic development conditioned by fac-

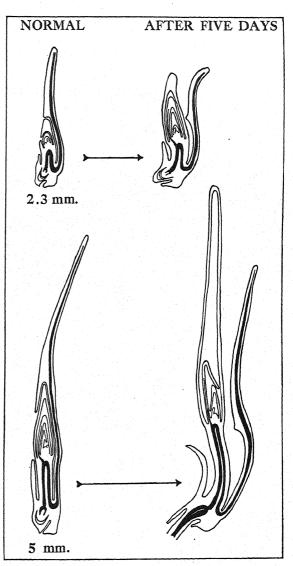


Fig. 5. Zizania aquatica; continuation of Fig. 4.

tors present in the growing ovary. No investigation has been made to determine the nature of these factors, but whatever they may be, we know that normal embryogeny is absolutely dependent upon them. Removed

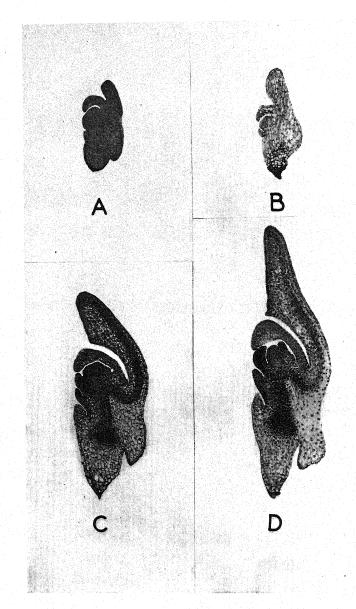


Fig. 6. Zizania aquatica; A, C, and D, photomicrographs of median longisections of normal embryos; A, 0.26 mm.; B, same, after 5 days in culture, now 0.43 mm.; C, 0.70 mm.; and D, 0.90 mm.

from their influence the embryo rapidly becomes a seedling, i.e., its axial development begins. The comparative study of embryos in vivo and in vitro offers a method of investigating the analysis of the factors which control normal embryogeny.

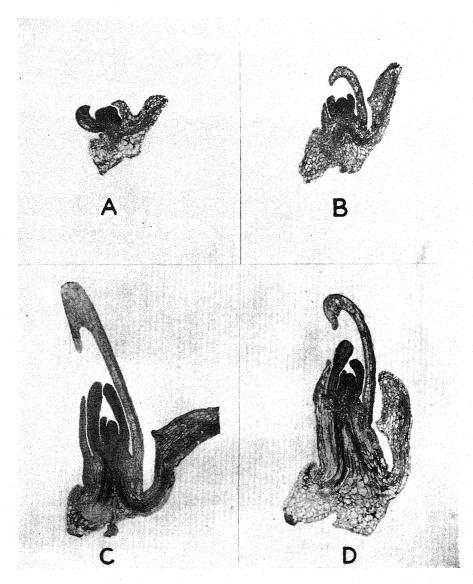


Fig. 7. Zizania aquatica; photomicrographs of median longisections of embryos of various sizes after 5 days culture on nutrient agar. Compare with fig. 4 for sizes of these embryos at time of removal from ovaries.

SUMMARY

1. The embryo of Zizania aquatica was chosen for this study because the marked elongation of the cotyledon and the epiblast during embryogeny in vivo provide a means of determining departures from the normal during development in vitro.

2. Embryos of different ages were dissected from their ovaries. Representative sizes were fixed, imbedded, sectioned and stained, and a corresponding set of embryos was placed on nutrient agar in Petri dishes. After 5 days in culture the embryos of this second group were sectioned for comparison with the normal embryos.

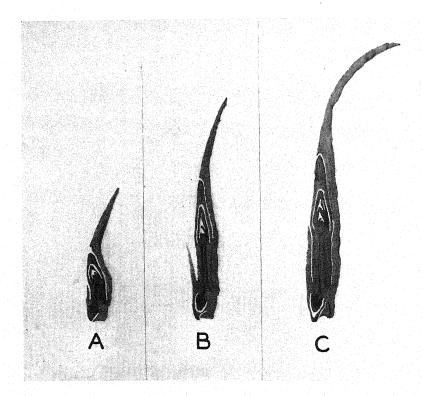


Fig. 8. Zizania aquatica; photomicrographs of longisections of normal embryos of different sizes. A, 2.3 mm.; B, 3.8 mm.; C, 5.2 mm. See fig. 5 for diagrams of A and C. Longisections of mature embryos differ in no important respect from C, except that the cotyledon usually attains a length of approximately 12 mm. See fig. 3.

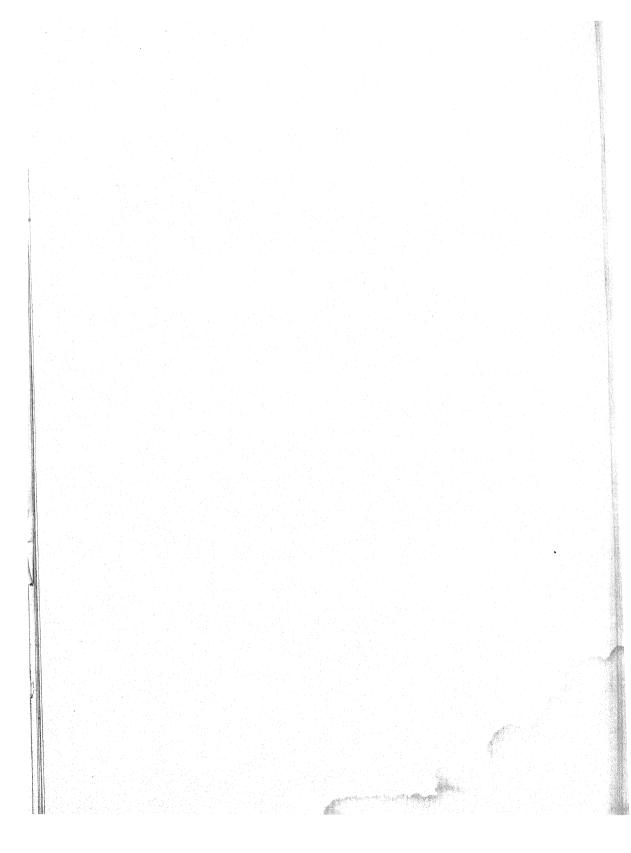
- 3. Embryos of all but the smallest sizes were grown to the seedling stage in culture. Small embryos took a somewhat longer time to reach the seedling stage. Embryos smaller than 0.4 mm. failed to reach the seedling stage.
- 4. Determinations were made of the time required after pollination for the development of the different sizes of embryos, in the course of normal embryogeny.
- 5. The normal development of embryos has been traced and compared with that of those grown in vitro. Growth in culture is generally character-

ized by *precocious* development of the shoot and retarded growth of the primary root. In older embryos elongation of the primary root is not appreciably retarded. Growth of the cotyledon and epiblast is arrested upon transfer to agar culture. Normal growth and development of the embryo is dependent upon its presence within the tissues of the parent plant.

University of Michigan¹
Ann Arbor, Michigan
Connecticut College
New London, Connecticut

Literature cited

- Avery, G. S., Jr. 1930. Comparative anatomy and morphology of embryos and seedlings of maize, oats, and wheat. Bot. Gaz. 89: 1-39.
- Bews, J. W. 1929. The world's grasses. London.
- Cannon, W. A. 1900. A morphological study of the flower and embryo of the wild oat, Avena fatua L. Proc. Calif. Acad. Sci. ser. III. Bot. 1: 329-362.
- Dietrich, K. 1924. Über die Kultur von Embryonen ausserhalb der Samen. Flora N.F. 17: 379-417.
- Hannig, E. 1904. Über die Cultur von Cruciferen-Embryonen ausserhalb des des Embryosacks. Bot. Zeitung 62: 45-80.
- LaRue, C. D. 1936. The growth of plant embryos in culture. Bull. Torrey Club 63: 365-382.
- Randolph, L. F. 1936. Developmental morphology of the caryopsis in maize. Jour. Agric. Res. 53: 881-916.
- Souèges, R. 1924. Embryogénie des graminees. Développement de l'embryon chez le *Poa annua* L. Compt. Rend. Acad. Sci. [Paris] 178: 860-862.
- Tukey, H. B. 1934. Artificial culture methods for isolated embryos of deciduous fruits. Amer. Soc. Hort. Sci. 32: 313-322.
- Van Tieghem, P. 1897. Morphologie de l'embryon et de la plantule chez les Graminées et les Cyperacées. Ann. Sci. Nat. Bot. VIII. 3: 259-309.
- White, P. R. 1934. Potentially unlimited growth of excised tomato root tips in a liquid medium. Plant Physiol. 9: 585-600.
- ¹ A part of this work was done while both authors were in residence at the University of Michigan Biological Station (no. 640 in the series of botanical papers from the Univ. of Mich.). All photomicrographs by Donald D. Irish, The Dow Chemical Company, Midland, Michigan.



A new green alga: Oedocladium Lewisii

L. A. WHITFORD (WITH PLATE 2)

Although Oedocladium protonema has not been collected since the genus was established by Stahl, five additional species have been described. The writer was fortunate enough to collect a seventh in autumn, 1936. For several weeks it was widely distributed but not abundant in lower piedmont North Carolina; and in December it was collected in the extreme eastern part of the State. Like most of the species it is terrestrial and is always associated with Vaucheria, Botrydium, liverworts, and mosses. It forms tiny colonies on very moist sandy or loam soil, that was plowed the current year. Half shaded areas in bottom-land fields are the most likely collecting places. To the naked eye it resembles moss protonema but is slightly yellowish green and grows in scattered tufts one to two millimeters in diameter. Rainy or cloudy and cool weather for several weeks is probably necessary for it to become abundant enough to be readily collected.

Oedocladium Lewisii sp. nov.

Monoica; oogoniis singulis, plerumque terminalibus, globosis, operculo inferior. Oosporis globosis, membrana triplici, omne levi vel mesosporio angulato (in sectione optica undulato), oogonium complentibus. Cellulis suffulcio sine pigmentum, saepe moribundus. Antheridiis ad 9-cellularibus, gametis masculis singulis. Cellulis vegetativus subcylindricis, cellula terminali apice conica. Cellulis vegetativis superterraneis $13-22\mu\times60-106\mu$. cell. veg. subterraneis $4-11\mu\times ad$ 257μ . Oogonis $45-70\mu$ diam. Oosporis $42-60\mu$. diam. Antheridiis $16-21\mu$ latis, $12-21\mu$ longis.

Herb. L. A. W. 550-554.

Monoecious; oogonium solitary, nearly always terminal, operculum inferior. Oospore globose with a triple membrane, the middle layer smooth or angulate (undulate in optical section) the other layers smooth, nearly or entirely filling the oogonium. Suffultory cell without color usually empty. Antheridia up to 9; sperm single. Vegetative cells subcylindric, terminal cells with conic apex, $13-22\mu\times60-106\mu$. Rhizoidal cells $4-11\mu\times(\text{up to})\ 257\mu$. Oogonium $45-70\mu\times48-70\mu$. Oospore $42-60\mu$ in diameter. Antheridium $16-21\mu\times12-21\mu$.

The species was collected in October and November at five stations in Wake County, North Carolina, and once each in Durham and Harnett counties. In late December it was also collected in Craven, Carteret, and Pamlico counties in the coastal plain.

There is a superficial resemblance to O. Hazenii, but the inferior operculum and empty suffultory cells readily separate it from all known species. It is the second described species with an operculum and the other character seems to be unique for the genus. In the last division of the suffultory cell, all of the chlorophyll and most of the cytoplasm migrates into the forming oogonium. A nucleus and a small amount of much vacuolated cytoplasm remains in the suffultory cell. By the time the oospore is mature this protoplasm has usually disintegrated leaving a dead cell supporting the oogonium.

Observation of living, dividing cells and studies of preserved material by simple microchemical methods, lead the writer to believe that cell division occurs according to the theory of Kraskovitz for Oedogonium. That is, when the ring forms in a dividing cell, it forms not as an isolated mass of new cell wall material laid down at that particular point, but is merely an inward bulging portion of a new wall layer laid down, and completely covering the inside of the mother cell (figs. 6, 8). The mother cell ruptures under the inward bulging portion (ring) and this stretches or extends itself to form the wall of the daughter cell. The cross wall is not a "floating" structure but forms in situ at the point of attachment, and after the nucleus and cytoplasm have migrated into the daughter cell. Branches are formed by the failure of the mother cell to rupture all the way around. In this case the ring bulges out through the slit formed on the side of the mother cell and forms the first cell of the new branch. Aberrant L-shaped cells sometimes observed, are good proof that branches form in this way (fig. 7). Rhizoidal or semi-rhizoidal cells continue to grow by intussusception near the tip of the cell. In this case most of the protoplasm, and chlorophyll if present, is concentrated in the distal end, leaving the other end of the cell colorless and vacuolate.

A more complete description of cell formation in *Oedocladium* will be published later

NORTH CAROLINA STATE COLLEGE,
RALEIGH

Explanation of plate 2

All drawings made with the aid of a camera lucida. Cells in figures 6, 7, and 8 swollen with 60-65% sulfuric acid.

Fig. 1. Young plant showing growth habit.

Fig. 2. Oogonium formation showing migration of chloroplast into the oogonium.

Fig. 3. Oogonium with colorless suffultory cell.

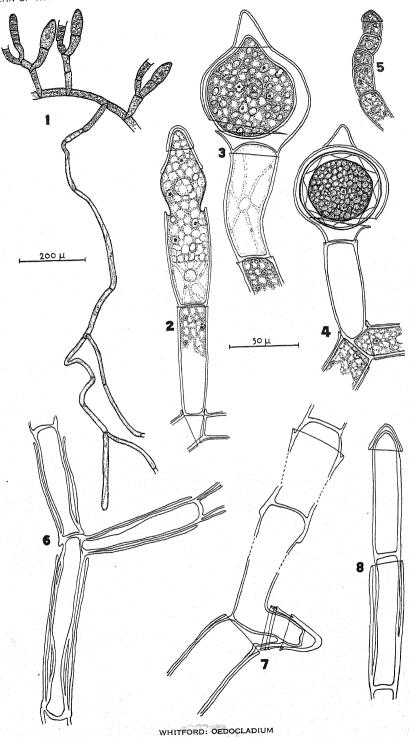
Fig. 4. Oogonium with mature oospore and empty suffultory cell.

Fig. 5. Antheridia.

Fig. 6. Cells swollen with strong sulfuric acid showing that after cell division has occurred cell walls have two or more complete layers.

Fig. 7. L-shaped cell resulting from incomplete rupture of mother cell wall.

Fig. 8. Showing that cell wall consists of one layer before division and of two layers after a cell has divided.



Literature cited

- Collins, F. S. 1918. The Green Algae of North America. Second Supplementary Paper. Tufts College Studies. Sci. Series 4: 1-106.
- Hirn, K. E. 1900. Monographie und Iconographie der Oedogoniaceen. Acta Soc. Fennicae 27: 1-394.
- Knapp, E. 1933. Ein neues Oedocladium aus Nord-Amerika (Ocd. Wettsteinii). Ber. d. deutschen Botan. Gesellsch. 51(1): 40-43.
- Kraskovitz, G. 1905. Ein Beitrag zur Kenntnis des Zellteilungsvorgänge bei Oedogonium. Sitzungsber. Akad. Wiss. Wien Math.-Nat. Kl. 114: 237-274.
- Stahl, E. 1891. Oedocladium protonema, eine neue Oedogoniaceen-Gattung. Pringsheim's Jahrb. für Wissensch. (1892) 23(3): 339-348.
- Tiffany, L. H. 1930. The Oedogoniaceae, a monograph. The author, Columbus, Ohio.
- . 1936. Wille's Collection of Puerto Rican Freshwater Algae. Brittonia, 2: 165-175.

Delphinium carolinianum and its allies

ROBERT F. MARTIN

Few genera of North American plants are more puzzling than the delphiniums. Among the entities differences in flower color, leaf segmentation, pubescence, and habit are often unaccompanied by tangible structural changes, and determination depends upon the weighing of several evasive and independently varying characters. The roots and seeds are reliable enough but they are, in general, essentially alike among closely allied species. Furthermore, a great deal of herbarium material lacks these organs.

No group is responsible for more confusion than the *Delphinium carolinianum* complex. The present notes result from examining a series of sheets preparatory to attempting a monograph of the genus in North America.

The first recognizable species of the group was described by Walter¹ as D. carolinianum. Michaux² redescribed this species as D. azureum, a name commonly encountered in literature and on herbarium labels. Dr. Blake³ has pointed out that Walter's specimen is only a fragment and not deter minable. I believe, however, it is safe to assume on the basis of distribution that Walter collected the species that has been accredited to him. More species have been added from time to time by Nuttall, D. Don, Huth, Greene, and Rydberg. Lately Miss Perry⁴ has contributed a variety. Most confusion exists in the application of Huth's, Greene's, and Rydberg's names.

In my opinion, use of the orientation of the spur, its degree of curvature, and the distance of the bracteoles from the receptacle to distinguish entities is unjustified. Throughout the genus the upper part of the pedicel and the receptacle are bent in anthesis so that the flower is horizontal or turned downward. Later by unequal growth in the pedicel, it is moved through 90° or 180° to an erect position, and this same growth causes the bracteoles to become remote.

Unless otherwise indicated, all specimens cited are in the United States National Herbarium. Those in the herbarium of the National Arboretum are followed by N. A. Those specimens found in both collections are followed by U. S., N. A.

¹ Walter, T., Flora Caroliniana p. 155. 1788.

² Michaux, A., Fl. Bor. Amer. 1:314. 1803.

³ Blake, S. F., Rhodora 17: 130. 1915.

⁴ Perry, L. M., Rhodora 39: 20-22.1937.

a. Seeds wing-margined

Pubescence glandular, at least in part.

Pubescence not glandular.

1. D. carolinianum (typical). 1a. D. carolinianum, var. crispum.

aa. Seeds squamellate, not wing-margined. b.

b. Flowers white, greenish or yellowish white, or blue tinged. Pubescence glandular, at least in part.

Pubescence glandular, at least in part. Pubescence not glandular.

bb Flowers blue.

2. D. virescens (typical).

2b. D. virescens var. camporum.2a. D. virescens, var. vimineum.

D. CAROLINIANUM Walt. Fl. Car. 155. 1788. D. azureum Michx., Fl. Bor. Am. 1: 314. 1803; D. Nortonianum Mack. & Bush, Trans. Acad. Sci. St. Louis 12: 82. 1902; D. azureum, var. Nortonianum Palmer & Steyermark, Ann. Mo. Bot. Gard. 22: 543. 1935; D. carolinianum, var. Nortonianum Perry, Rhodora 39: 20. 1937.

I am unable to distinguish D. Nortonianum from large, deep blue states of D. carolinianum. In all its characters, size and color excepted, it seems identical.

Georgia to Texas and Missouri. Also from Florida to Virginia, according to Small.

GEORGIA: Bibb Co., Biltmore Herb (3767c); ALABAMA: Lee Co., Pollard & Maxon 15; MISSISSIPPI: Hinds Co., Cook, May 24, 1925; TEXAS: Walker Co., Dixon 555; Woods Co., Reverchon 4341; OKLAHOMA: Leflore Co., Blakeley 1419; ARKANSAS: Nevada Co., Hollister 12; MISSOURI: Jackson Co., Bush 377, isotype of D. Nortonianum.

1a. D. CAROLINIANUM, var. CRISPUM Perry, Rhodora 39: 21. 1937.

In addition to the absence of glandular hairs, the carpels seem longer than in typical *D. carolinianum*. The specimen of Patterson here cited has mature seeds quite like those of the species.

Alabama to Arkansas, north to Missouri and Illinois.

ALABAMA: Perry Co., Smith, 187(6?); ARKANSAS: Carroll Co., Palmer 5585; MISSOURI: Barry Co., Bush 228; ILLINOIS: Henderson Co., Patterson, no date given.

 D. VIRESCENS Nutt. Gen. N. Am. Pl. 2: 14. 1818: D. azureum β virescens Huth, Helios 10: 34. 1892: D. Penardi Huth, loc. cit: D. albescens Rydb, Bull. Torrey Cl. 26: 583. 1899: D. carolinianum, var. Penhardii A. Nels. in Coult. & Nels. New Man. Rocky Mtn. Bot. 193. 1909: D. virescens, var. Penardi Perry, Rhodora 39: 21. 1937.

This is the common species of the prairies and plains, and ranges into the foothills of the Rockies. Huth's *D. Penardi*, I am unable to distinguish. Attempts have been made to separate it as the form with the upper part of the stem eglandular. It appears, however, that the glandular hairs may be present on any or all parts of the stem indiscriminately.

Louisiana and Texas, north to Colorado and Wisconsin.

LOUISIANA: Jeff Davis Parish, Palmer 7672; TEXAS: Brazos Co., Palmer 9369; Victoria Co., Tracy 9243; OKLAHOMA: Woods Co., Stevens 551; KANSAS: Riley Co., Norton (Kans. St. Ag. Col. 8); NE-BRASKA: Grant Co., Marsh, June 25, 1916, (N. A., U. S.); SOUTH DAKOTA: Moody Co., Ball 875; MINNESOTA: Hennepin Co., Mearns 270; IOWA: Harrison Co., Eggleston 15135; COLORADO: Arapahoe Co., Eggleston 11216, (N. A., U. S.)

2a. D. virescens, var. vimineum (D. Don), comb. nov.: D. vimineum D. Don in Sweet Brit. Flow. Gard. Ser. 2, pl. 374. 1838: D. azureum, var. vimineum A. Gray, Bot. Gaz. 12: 52. 1887: D. macroseratilis Rydb. Bull. Torrey Club 26: 585. 1899.

Because of its rugose-squamellate seeds this form belongs here rather than with D. carolinianum, which it resembles in habit.

TEXAS: Harris Co., Palmer 9620; Kerr Co., Heller 1723;

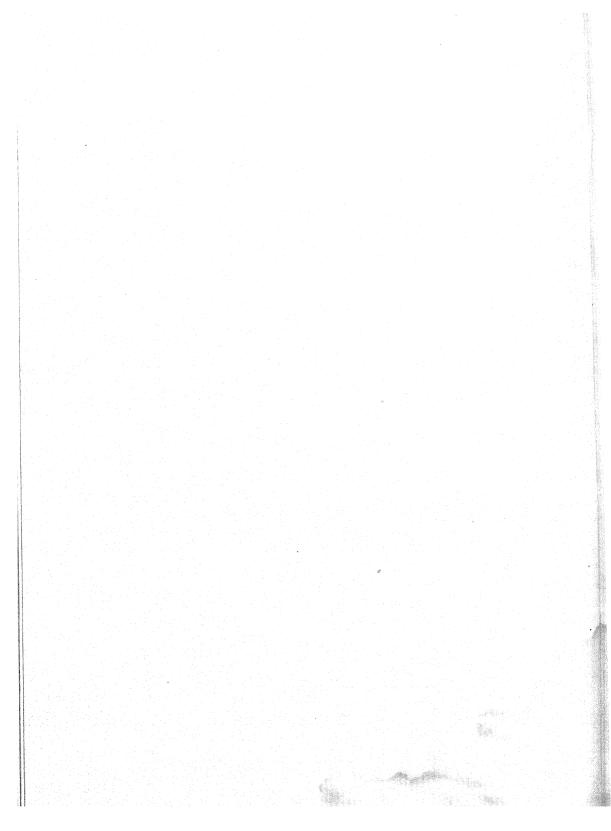
2b. D. virescens, var. camporum (Greene), comb. nov.: D. camporum Greene Erythea 2: 183. 1894: D. Wootoni Rydb., Bull. Torrey Club 26: 587. 1899.

Doctor Greene's name has been considered a synonym of D. Penardi Huth and specimens of this variety are generally determined as D. Penardi It is clear, however, from Green's description and from plants determined by him that he described the eglandular plant of the Mexican border states. Huth's plant from his description was glandular and therefore, as I see it, the same as typical D. virescens. Var. camporum may be distinguished by the subscapose stem and often by the blue tinged flowers.

Texas to Arizona.

TEXAS: Bexar Co., Havard, March 1882; Terrell Co., Palmer 33546; NEW MEXICO: Dona Ana Co., Wooton, May 26, 1905; ARIZONA: Cochise Co., Eggleston 19863.

DIVISON OF PLANT EXPLORATION AND INTRODUCTION, BUREAU OF PLANT INDUSTRY, WASHINGTON



The cultural characteristics of the species of Fomes^{1,2}

W. A. CAMPBELL

Within the past several years, the identification of the causal organisms of timber decay has become of considerable importance especially in connection with improvement cuttings in second-growth hardwood timber. Some investigators have been puzzled by the multiplicity of fungous forms which may be isolated from decayed wood and have felt that the positive identification of these fungi is a hopeless task. This study has been undertaken in order to work out a practical system whereby fungi from decayed wood may be identified and to study the cultural characteristics of the species of a single genus. The genus *Fomes* was selected because a number of isolates of the different species were already available and, since the sporophores are perennial, additional isolates could be obtained at any time.

REVIEW OF THE LITERATURE

Since Hartig's discovery of the relation between the mycelium of a fungus present in wood and the condition of decay which existed, many investigators have demonstrated that this mycelium, when isolated under aseptic conditions, could be made to grow upon artificial media in test tube and Petri dish cultures.

The following investigators have pointed out that cultural characteristics are valuable means for the identification of the organisms of decay: White (1910) first cultured a member of the genus Fomes, using Fomes applanatus, and made observations on cultural characteristics; Baxter (1924) pointed out the possibility of using growth rate to separate fungi closely related in form and demonstrated the production of two kinds of secondary spores in culture by F. fraxineus; Mounce (1929) made extensive observations on the cultural characteristics of Fomes pinicola using malt agar as a standard medium. The most complete study of cultural characteristics was made by Long and Harsch (1918) who tested a number of wood destroying fungi including ten species of Fomes. They were particularly interested in the development of sporophores in culture. They originated a number of descriptive terms which have been used in the

¹ Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany, The Pennsylvania State College, State College, Pa., August, 1935.

² The writer is particularly indebted to Dr. L. O. Overholts, of the Department of Botany, The Pennsylvania State College, for his suggestion of the problem and for his encouragement and aid during the course of the experimentation and during the preparation of this article.

present study. Fritz (1923) demonstrated beyond a doubt that individual species of wood-destroyers produced very characteristic mats in culture and that these characteristic mats were constant for a given species. Snell, Hutchinson and Newton (1928) demonstrated that closely related forms could be separated by growth rate at constant temperatures. Sluzalis (1933) worked out the cultural characteristics of a number of fungi, paying particular attention to the formation of secondary spores. Within the last few years Cartwright (1929, 1934), Verral (1934) and Baxter (1932) have made more or less extensive studies of wood-destroyers, including many species of *Fomes*, in culture, demonstrating the practicability of making identifications of sporophores and rots on the basis of cultural characteristics.

MATERIALS AND METHODS

The purpose of this study has been to work out a suitable system for the identification of *Fomes* species in culture, based upon as simple a procedure as possible. With this in mind, the fungi to be identified were grown on a single kind of agar, for a limited period, in Petri dishes at room temperature. Identification was then based upon macroscopic and microscopic characters. To this basic procedure has been added (1) growth at constant temperatures and (2) reactions obtained with tannic and gallic acid media. At all times, however, emphasis has been placed upon the development of a simple, practical technique which may serve as the basis for future studies on the cultural characteristics of other fungi.

Media. Since personal observations and the experience of others indicate that nothing of great importance is to be gained by growing a fungus on a variety of agars, malt agar, which has been recognized for some time as the standard medium for culturing wood-destroying fungi, was chosen as the medium to be used in this study. Other agars, when used, were merely for the sake of providing supplementary data. The malt agar was prepared by dissolving 20 grams of agar in 1 liter of distilled water either in the autoclave or over an open flame. When the agar was dissolved, 15 grams of Difco malt extract was added and the resulting solution poured into 500 cc. flasks and sterilized for 20 minutes at 15 pounds pressure. The weight of materials and time of sterilization were carefully checked in order to make each batch comparable.

No attempts were made to adjust the pH of the malt agar. Test samples taken at various times indicated a range of from 5.2 to 5.8. Since wood-destroying fungi prefer a slightly acid medium and since the pH may vary within rather wide limits for these fungi, the control of pH within these narrow limits was not considered important.

33

Tannic and gallic acid media used to differentiate between brown-rot fungi and white-rot fungi were prepared according to Bavendamm's (1928) suggestion, in total concentrations of 0.5 per cent. Since it is impossible to sterilize malt agar containing tannic and gallic acid, the malt agar was prepared as given above using instead of 1000 cc. of water, 800 cc. The proper amounts of the tannic or gallic acids were dissolved in 200 cc. water and sterilized. While still hot the two were mixed together and poured into Petri dishes. When only a few plates of tannic acid medium or gallic acid medium were needed, the malt agar was poured into the dishes and a small amount of the acid dropped in with a scalpel. This short method gave results comparable to more accurate methods since the concentrations of the tannic and gallic acids may vary considerably without affecting results.

No attempt was made to accurately measure the amount of agar used in Petri dish cultures. A thick layer, however, was poured into each dish, considerably in excess of the amount actually required by the fungus, in order to make sure that moisture content would not be reduced appreciably in the 14 days that the dishes were in use.

For stock cultures, 18 mm. test tubes were used. These tubes were filled with 15 cc. of agar and given a comparatively short slant in order to reduce the surface exposed to air. For subcultures a longer slant was used, as here the object was to secure a surface from which inoculating material might be taken rather than to prevent drying of the agar.

Treatment of cultures. The stock cultures were kept in racks in a cupboard where they received but weak diffused light. These cultures were renewed every four months.

Whenever inoculations of Petri dishes were to be made, subcultures were started from 2 to 3 weeks in advance. These subcultures were usually made in Petri dishes although long-slanted test tubes were also used.

In order to secure the most constant results, the following procedure was adopted. Material for the inoculum was taken from near the outer margin of the mats, care being taken to include some of the superficial hyphae as well as the submerged hyphae, the size of the piece being maintained as constant as possible, about 3 mm. square. This was placed with the mycelium side down upon the agar and gently patted in order to bring it into close contact. All transfers were made in a small room with doors and windows closed. No precautions were observed other than mopping up thoroughly with mercuric chloride just prior to transferring, and confining transfer work to the early hours before any sweeping or general moving about of people had stirred up the dust. Very few contaminations resulted and these were never serious enough to interfere with the work.

Cultures to be grown at room temperature were left on the desk in the same room used for transfer work. This room was on the southwest side of the building and had one window. The distance from the window varied from 10 to 12 feet. The shades were adjusted to provide diffused light at all times, although no attempt was made to keep the amount of light constant. Cultures grown at constant temperatures were kept in complete darkness.

In order to eliminate variable results at higher temperatures when working with constant temperature ovens, cultures to be incubated at 36° C were kept at room temperature for 48 hours prior to being placed in the oven, those at 31°, 24 hours, those at 21° and 26° were placed there directly after inoculating. At the higher temperatures it was felt advisable to allow the mycelium to make some growth into the agar before being placed under, in many cases, adverse temperatures for growth and development.

Recording data. Data as to rate of growth, appearance of mat, color, and microscopic features were taken from Petri dish cultures at intervals of seven and fourteen days. Records for test tube cultures were taken at one, two, four and eight weeks. Observations as to macroscopic and microscopic features were taken at least three different times, corresponding to different seasons of the year for each species, and the final description is a composite of the separate descriptions. Colors are described in terms of Ridgway's Color Manual.

Photographs of Petri dish cultures were made at intervals of seven days for fast growing species and at fourteen days for slower growing species. These photographs are designed to show the more usual characteristics of the cultures rather than exceptions.

In all cases emphasis is laid upon the fact that the final descriptions are the result of numerous observations made over a period of 18 months. In this way it has been possible to observe variations of individual cultures under conditions that are bound to vary from season to season.

Source of cultures. Most of the cultures used were isolates obtained from sporophore tissue. Some isolates from the rotted wood were also used. Most of these cultures were available from Dr. L. O. Overholts' collection at The Pennsylvania State College; additional ones were secured from Mr. R. W. Davidson, Office of Forest Pathology, Washington, D. C.; Dr. Irene Mounce, Central Experimental Farm, Ottawa, Canada; Dr. J. S. Boyce, Osborn Botanical Laboratory, New Haven, Conn.; Dr. W. H. Snell, Brown University, Providence, R. I. Other collectors have supplied smaller numbers of cultures and additional ones were obtained from time to time by trips into the field. In most cases identification of the sporo-

phores from which cultures were made has been checked by Dr. Overholts. In all, 31 species of Fomes are reported on in this investigation. This includes the several varieties of F. igniarius and the one variety of F. robustus, as well as the sterile fungus tentatively designated as the Sterile Fomes. One hundred and seventy-nine separate isolations of the Fomes species have been examined, distributed as follows among the different species: F. annosus, 4; F. applanatus, 12; F. Calkinsii, 4; F. conchatus, 5; F. densus, 4; F. Everhartii, 11; F. fomentarius, 12; F. fraxineus, 2; F. fraxinophilus, 12; F. fulvus, 2; F. geotropus, 2; F. igniarius, 12; F. igniarius var. laevigatus, 8; F. igniarius var. populinus, 4; F. juniperinus, 1; F. lobatus, 3; F. marmoratus, 3; F. meliae, 2; F. officinalis, 4; F. ohiensis, 1; F. Pini, 7; F. pinicola, 18; F. rimosus, 11; F. robustus, 8; F. robustus var. tsugina, 4; F. roseus, 5; F. scutellatus, 5; F. subroseus, 9; F. tenuis, 2; F. torulosus, 2; Sterile Fomes, 1. Of the species listed above, to my knowledge, the following have not been cultured previously or at least accounts of their cultural characteristics have not appeared in the literature: F. Calkinsii; F. con chatus; F. densus; F. geotropus; F. juniperinus; F. lobatus; F. marmoratus; F. meliae; F. ohiensis; F. robustus; F. scutellatus; F. tenuis; F. torulosus

DESCRIPTION OF CULTURES

and the Sterile Fomes.

In the descriptions of cultures an attempt has been made to include all variations that may be expected within a given species when grown on malt agar, at room temperature, in diffused light. Where a number of isolations were available for any species, this desideratum is at least approximated. Where only one or two isolations were available, the description can apply only to these isolations and may or may not be characteristic of the species as a whole. The phrase, Type Culture, is used to indicate an isolate which exhibits all the diagnostic characteristics of the species in question, and is a valid culture to be used for purposes of comparison. In case other investigators are interested in these Type Cultures, transfers of the same will be maintained at The Pennsylvania State College and have been sent to the Division of Forest Pathology, Washington, D. C.

Growth at seven days and fourteen days is expressed as the diameter of the colony in centimeters. The figures given indicate the range which may be expected from cultures grown in diffused light at room temperature. If a culture grew 6 to 7 cm. in seven days its growth has been described as rapid; if from 5 to 6 cm., moderately rapid; from 3 to 4 cm., slow; and from 1 to 3 cm., very slow.

Records of growth at constant temperatures are expressed as average colony diameters for cultures kept in total darkness. It is not feasible to

compare growth rates for cultures kept in dark with those maintained in light at the same temperature as light may considerably affect growth rate.

Texture of mat is described by the following terms taken for the most part from Long and Harsch's list:

Appressed: Mycelium which is prostrate on surface of agar.

Raised: Forming a mound on agar as opposed to appressed.

Cottony: Erect, rather long mycelium spreading in all directions.

Downy: Short, fine hairs loosely scattered over surface of mat giving it a downy appearance.

Felty: Matted with intertwined hairs resembling felt.

Woolly: A dense mass of mycelium, consisting of long, tortuous, matted hairs.

Plumose: Tufts of mycelium with a central axis from which short hyphae radiate. Silky: Long parallel threads of mycelium, more or less prostrate like combed silk

Nodulose: Forming definite nodes or bunches.

Tufted: Forming tufts.

Floccose: Thin, cottony pubescence, collected in very minute tufts.

Pulverulent: Having a powdery or dusty appearance.

Poroid: Covered with pores.

Homogeneous; Having same appearance throughout.

Mat broper: Portion of mat in direct contact with agar.

Central zone: In case mat is divided into definite areas, the portion about center.

Marginal zone: Part of mat surrounding central zone.

Margin proper: Region of advancing growth.

Fimbriate: Possessing a fringed edge.

Submerged hyphae: Hyphae growing in contact with or through agar.

Superficial hyphae: Aerial hyphae usually forming surface of mat.

In case it has been necessary to make intermediate distinctions between two of the above terms, for example between floccose and cottony, then the compound word, *floccose-cottony*, was used.

In case of reaction with tannic acid, a strong reaction indicates that the diffusion zone formed is dark brown and extends considerably beyond the margin of the colony; moderately strong, means that the zone is lighter brown and diffuses to a lesser extent; medium, means that the zone is light brown and ordinarily not extending beyond the margins of the mat; faint, indicates that the reaction is light brown, sometimes difficult to distinguish from the color of the mat proper, and found only under the older portions of the mat. Usually strong reactions will appear in at least 48 hours, while medium and faint reactions will require from four to four-teen days to manifest themselves. In case the reaction is negative no discoloration of the agar occurs.

If no secondary spores occur, no mention of spores will be found in the description. Structures not mentioned in the descriptions should be considered as lacking.

1. Fomes annosus (Fries) Cooke. Type Culture: FP-53378-S. Figures 1-3, 99.

Growth rapid, mat 6–8 cm. in 7 days; typical culture white, loose, floccose-cottony to appressed-cottony, homogeneous, azonate, at times much appressed and compacted about center, decidedly pulverulent; more cottony forms vegetative with few conidia, while appressed forms produce conidia in abundance; margin colorless or faintly white, coarsely fimbriate; condiophores very numerous to rare, borne on aerial hyphae with inflated, subglobose tips, 9–15 μ diameter, covered with numerous sterigmata; conidia obovoid, 5–8×3.5–6 μ ; submerged hyphae 3–4 (–8) μ , with cross-walls but no clamps; aerial hyphae 6–8 μ , granular with deeply staining contents; growth at constant temperatures, 5.5 cm., 21°; 8.0 cm., 26°; 4.3 cm., 31°; 0 cm., 36°; strong reaction with tannic acid media.

In 14 days mat appressed-floccose-cottony to floccose-cottony, usually azonate, pulverulent about inoculum or over entire surface, white, sometimes slightly cream colored; odor faint to prominent, musty.

Test tube cultures. White to cream colored up to 4 weeks, becoming cinnamon drab to drab in 8 weeks, mat fragile, pulverulent, at times forming poroid areas made up of closely interwoven hyaline hyphae, thickwalled, uniformly 2μ ; no basidia; globose, ellipsoid to short cylindric or irregular-shaped, terminal chalmydospores with definite hyaline wall, $9-15\times6-12\mu$, fairly abundant, intermingled with hyaline hyphae.

Distinguishing characters. The production of characteristic conidiophores and conidia separates Fomes annosus from all other Fomes species reported here.

2. Fomes applanatus (Pers.) Gill. Type Cultures: 17182-S, 17184-S. Figures 4-8, 100.

Growth slow, mat 2.5–4 cm. in 7 days, typically appressed, thin, colorless to faintly white or chalky white, downy or pruinose, fragile, usually slightly zonate, central portion often much compacted, pruinose-pulverulent, white, forming a tough crust on agar in contrast to fragile, thin, marginal portion; margin proper appressed, colorless, even; submerged hyphae $2-4(-5)\mu$, much branched, with abundant clamps; superficial hyphae $2-3(-4)\mu$, either resembling submerged hyphae and bearing numerous irregularly divided, staghorn branches, or thick-walled, hyaline; cuticular bodies abundant to rare in compacted central zone, globose, up to 20μ ; growth at constant temperatures 4.1 cm., 21° ; 5.0 cm., 26° ; 5.5 cm., 31° ; 1.0 cm., 36° ; moderately strong reaction with tannic acid media.

In 14 days mat 5-8 cm. in diameter, appressed, thin, fragile, colorless

to white, usually slightly zonate, downy to pulverulent or pruinose, with compacted white central zone. Unusual forms at times more compacted and much slower growing, or cottony and growing at a faster rate. Cuticular bodies more abundant; odorless.

Test tube cultures. Mat white up to four weeks with numerous yellowish compacted masses of crystalline material common along edge of mat on agar cylinder, tough, at times considerably wrinkled. Deepest colors developed in eight weeks mouse gray and Quaker drab, fruiting body produced in only one instance culture F-496, with few mature basidiospores, truncate, light brown $6-8\times4-5\mu$. On potato-dextrose producing a much wrinkled and contorted mat.

Distinguishing characters. F. applanatus is readily recognized by the presence of staghorn branches on superficial mycelium and by the absence of chlamydospores. F. fraxineus which produces staghorn branches on

Explanation of figures 1-53

Figs. 1–3. Fomes annosus. 1, Conidiophore. 2. Chlamydospores from poroid areas. 3. Hyaline hyphae from poroid areas.

Figs. 4-8. F. applanatus. 4. Submerged hypha. 5, Superficial hypha. 6. Staghorn branches. 7, Cuticular cells. 8, Basidiospores.

Figs. 9, 10. F. Calkinsii. 9, Submerged hypha. 10, Superficial hypha.

Figs. 11, 12. F. conchatus. 11, Submerged hypha. 12, Superficial hypha.

Figs. 13, 14. F. densus. 13, Submerged hypha. 14, Superficial hypha.

Figs. 15, 16. F. Everhartii. 15, Submerged hypha. 16. Superficial hypha.

Figs. 17-19. F. fomentarius. 17, Submerged hyphae. 18, Superficial hyphae. 19, Chlamydospore.

Figs. 20–26. F. fraxineus. 20, Submerged hypha. 21, Superficial hypha. 22, Staghorn branches. 23, Large chlamydospores. 24, Small chlamydospores. 25, Basidia. 26, Basidiospores.

Figs. 27–30. F. fraxinophilus. 27, Submerged hypha. 28, Superficial hypha. 29, Large chlamydospores. 30, Small chlamydospores.

Figs. 31–35. F. fulvus. 31, Submerged hypha, 32, Superficial hypha. 33, Incrusted hypha. 34, Basidia and paraphyses. 35, Basidiospores.

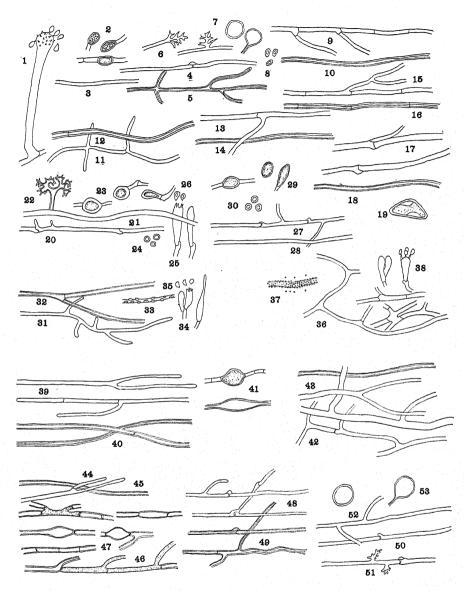
Figs. 36–38. F. geotropus. 36, Submerged hyphae. 37, Incrusted hypha, 38, Basidia and basidiospores.

Figs. 39-41. F. igniarius. 39, Submerged hyphae. 40, Superficial hyphae. 41, Chlamydospore-like bodies and hyphal swellings.

Figs. 42, 43. F. igniarius var. laevigatus. 42, Submerged hyphae. 43, Superficial hypha.

Figs. 44-47. Fomes igniarius var. populinus. 44, Submerged hypha. 45, Superficial hypha. 46, Submerged hyphae broken up into short cells. 47, Hyphal swellings. Figs. 48, 49. F. juniperinus. 48, Submerged hyphae. 49, Superficial hyphae.

Figs. 50-53. F. lobalus. 50, Submerged hyphae. 51, Staghorn branches. 52, Superficial hypha. 53, Cuticular cells.



Figs. 1-53. (See opposite page for legend)

superficial mycelium produces chlamydospores in abundance. F. applanatus cannot be separated with certainty in every instance from F. lobatus. However, the latter species usually has a pronounced compacted yellowish to drab central zone and a loose-cottony or only slightly compacted marginal zone.

3. FOMES CALKINSII (Murrill) Sacc. & D. Sacc. Type Culture: 14667-S. Figures 9, 10, 101.

Growth slow, mat 2–3 cm. in 7 days, white at margin, pale orange yellow or occasionally deepening to antimony yellow over central portion, raised, compacted, woolly to felty, often with faint narrow zones; margin white, short cottony, even; submerged hyphae $2-5(-6)\mu$. with cross-walls but no clamps, hyphae under colored portion of mat thin-walled, brownish with abundant cross-walls spaced at short intervals; superficial hyphae $2-3(-4)\mu$, thick walled, brown, with few cross walls, little branched; growth at constant temperatures 2.0 cm., 21° ; 2.5 cm., 26° ; 2.5 cm., 31° ; trace, 36° ; strong reaction with tannic acid medium.

In fourteen days mat 4-5 cm., white at margin to pale orange yellow and antimony yellow over central portion, raised, compacted, woolly to felty, spongy; margin white short cottony, even; odorless.

Test tube cultures. Mat in four weeks forming definite fruiting pad on slant, tough, heavy, from mustard yellow, through antimony yellow to yellow ochre and buckthorn brown.

Distinguishing characters. F. Calkinsii is difficult to separate from F. robustus but the former is more delicate, lighter colored and grows somewhat slower, and becomes more pallid in the dark. F. Calkinsii is inhibited entirely at 36° C while F. densus is able to make good growth. Similarly F. Calkinsii may be separated from F. conchatus, F. Everhartii, F. rimosph and F. torulosus on temperature relations.

4. FOMES CONCHATUS (Pers.) Gill. Type culture: 524 Mad. Figures 11, 12, 102.

Growth very slow, mat 1–2 cm. in 7 days, white with at times a yellowish tinge about inoculum; thin, cottony to thick, felty-cottony, too small to possess many distinctive features and consisting of a white cottony, relatively undifferentiated mass of hyphae; margin white, cottony, fimbriate; submerged and superficial hyphae not distinct, 2–5 μ , with cross-walls but no clamps; growth at constant temperatures, 1.7 cm., 21°; 2.3 cm., 26°; trace, 31°; 0 cm., 36°; strong reaction with tannic acid medium.

In fourteen days mat 2.5-4 cm., somewhat variable with few dis-

tinctive features, usually raised, compacted felty-cottony about center to more loosely-cottony at margin, compacted central zone varying in color from fawn to buckthorn brown, often partially obscured by white to yellowish superficial covering; marginal zone chalky white; margin proper white, cottony, fimbriate; colored superficial hyphae uniformly $2-5\mu$, thick-walled, non-staining, branched, with abundant cross-walls, yellow color of superficial hyphae diffusing strongly in KOH solution; globose vesicular bodies common in some cultures, rare in others, mostly terminal, up to 20μ in diameter; odorless.

Test tube cultures. In 4 weeks mat forming pad on slant, usually uneven on agar cylinder, varying considerably in color from warm buff to yellow ochre and buckthorn brown.

Distinguishing characters. Fomes conchatus is one of the slower growing colored species of Fomes with a restricted temperature range being almost completely inhibited at 31° C. It can be distinguished from F. Pini by color and temperature relations and from F. igniarius var. populinus by more rapid growth and by its chalky white mat in early stages and absence of odor.

5. Fomes densus Lloyd. Type culture: FP-52033-S. Figures 13, 14, 103.

Growth slow, mat in 7 days 2–3 cm., straw yellow at margin, gradually deepening to mustard yellow and primuline yellow over inoculum, raised, loosely felty-cottony to woolly, at times compacted, homogeneous, azonate; margin proper even, colorless; submerged hyphae 3–5(–7) μ , with few cross-walls and no clamps; superficial hyphae moderately thick-walled, yellowish 2–4 μ ; growth at constant temperatures 2.0 cm., 21°; 2.6 cm., 26°; 4.7 cm., 31°; 2.0 cm., 36°; strong reaction with tannic acid medium.

In 14 days mat 4.5–6 cm., dense, closely compacted, woolly to felty-cottony, nodulose, raised considerably above agar, homogeneous, straw yellow at margin to mustard yellow and primuline yellow at center, superficial raised portion tough, spongy, separating freely from agar, turning ochraceous buff when touched with KOH, later light brown; odorless.

Test tube cultures. In 4 weeks mat raised, compacted, with definite fruiting pad on slant, homogeneous in color and texture, tough antimony yellow and yellow ochre.

Distinguishing characters. F. densus does not separate readily from F. robustus and F. Calkinsii. However, it does show a considerably faster growth rate at 31° than either of these and the yellow color which rarely deepens to antimony yellow is quite distinctive, since both F. Calkinsii and F. robustus become yellow ochre or darker in Petri dish cultures in 14

days. Both F. Calkinsii and F. robustus turn brown when touched with KOH without going through an intermediate ochraceous buff stage.

6. FOMES EVERHARTII (Ell. & Gall.) von Schrenk Type culture: 17412-S. Figures 15, 16, 104.

Growth slow, mat 2–3 cm. in 7 days, dark, approximately Sudan brown, fragile, not separating from agar, superficial covering thin to dense, ochraceous buff and antimony yellow at center to pale yellow or white at margin, often with a greenish yellow sheen, silky to silky-cottony, partially to completely obscuring color of mat proper; margin colorless to white, appressed to cottony, fimbriate; submerged hyphae from growing tip $2-4(-6)\mu$, thin-walled, staining readily with eosin, few crosswalls and no clamps, from mat proper $2-4(-6)\mu$, thick-walled with brownish content and with abundant cross-walls; superficial hyphae, $2-3(-4)\mu$, thin to moderately thick-walled, darkening in KOH; growth at constant temperatures 2.0 cm., 21°; 3.2 cm., 26°; 3.6 cm., 31°; 1.5 cm., 36°; strong reaction with tannic acid medium.

In 14 days mat 4–6 cm., mat proper Sudan brown, closely compacted to agar, rather thick; superficial covering antimony yellow or pale yellow at center to white at margin, silky to silky-cottony, partially to completely obscuring color of mat proper; odorless.

Test tube cultures. Mat in 4 weeks Dresden brown to mummy brown, thick, clinging to agar, superficial covering silky-cottony, antimony yellow to yellow ochre, becoming faded with age, finally warm buff through cinnamon buff to honey yellow.

Distinguishing characters. In general F. Everhartii if grown in light can readily be distinguished from F. igniarius, F. rimosus and F. densus by dark mat proper and by silky superficial covering, often with a greenish tint, and usually turning vinaceous when rubbed with KOH.

7. FOMES FOMENTARIUS (L.) Gill. Type culture: 17041-S. Figures 17-19, 105.

Growth rapid, mat in 7 days 6–7 cm., white to cream colored or light ochraceous buff and light ochraceous salmon, ochraceous color localized about inoculum or covering entire surface, azonate, homogeneous, closely appressed-cottony to appressed-velvety, forming a distinct, somewhat tough film on agar; margin white or colorless, fimbriate; chlamydospores rare or absent, ellipsoid, ovoid, or irregular, $20-28\times12-18\mu$, with thick hyaline wall; submerged hyphae, $3-5\mu$, with abundant clamps; superficial hyphae $2-4\mu$, hyaline or colored, thick-walled, uniform, without clamps; growth at constant temperatures 5.0 cm., 21° ; 7.0 cm., 26° ; 6.4 cm., 31° ; trace 36° ; strong reaction with tannic acid medium.

In 14 days mat solidly light ochraceous buff to buckthorn brown or with irregular white or cream colored areas, rarely entire mat white or cream colored, forming tough, thin film on agar, surface appressed-velvety; margin against glass often forming distinct, yellowish papillae which contain crystalline material; odor indistinct, sweetish.

Test tube cultures. In 4 weeks mat appressed-velvety, cream colored to buckthorn brown, with numerous yellowish papillae against glass later darkening to cinnamon brown and Dresden brown.

Distinguishing characters. F. fomentarius can readily be distinguished in culture by the thin, velvety, appressed mat and by lack of pore surfaces and vesicular bodies. The only species that it superficially resembles, F. marmoratus, produces conspicuous cuticular or vesicular bodies. The yellowish papillae against the test tube glass is characteristic of F. fomentarius.

8. FOMES FRAXINEUS (Bull. ex Fries) Cooke-Type culture: FP-57061-S. Figures 20-26, 106.

Growth moderately rapid, mat 5–6 cm. in 7 days, white, homogeneous, appressed, pulverulent to granular about inoculum to appressed coarse cottony near margin; margin proper faintly white, very coarsely fimbriate; chlamydospores very numerous, mostly globose to lemon-shaped, 10–15 μ in diameter, when mature with heavy hyaline wall up to 4μ thick; occasional cultures exhibit few to many clavate, immature basidia which resemble irregular-shaped chlamydospores; submerged hyphae up to 4μ , with abundant clamps; superficial hyphae 2–4 μ , hyaline, thick-walled, often bearing numerous dichotomously divided staghorn branches from tips and sides; growth at constant temperatures 4.0 cm., 21°; 6.5 cm., 26°; 8.5 cm., 31°; 2.5 cm., 36°; strong reaction with tannic acid medium.

In 14 days mat white, appressed, pulverulent to granular or appressed, coarse cottony, with raised velvety patches and at times with faint to prominent poroid areas, white to faintly vinaceous; chlamydospores of type described at 7 days very numerous, in addition poroid areas contain small, subglobose chlamydospores $6-8\times5-6\mu$; immature basidia common in poroid areas, mature basidia rare, clavate $8-10\mu$ diameter; basidiospores ellipsoid $5-7\times3-4\mu$; odorless.

Test tube cultures. Mat white with sporophore developing on lower half of slant in 4 weeks, pores deep purplish vinaceous, producing subglobose chlamydospores in great abundance.

Distinguishing characters. F. fraxineus may be distinguished from F. fraxinophilus, which it resembles very closely in appearance, by heavy walled chlamydospores, by the staghorn branches on superficial mycelium,

and by the vinaceous color of the pore surface as produced in tube cultures. It may be distinguished from F. applanatus and F. lobatus by production of chlamydospores and by the formation of pores in tube cultures.

9. FOMES FRAXINOPHILUS (Peck) Sacc. Type culture: 15159-R. Figures 27-30, 107.

Growth moderately rapid, mat 4–5 cm. in 7 days, white, appressed nodulose-cottony to appressed velvety-cottony, often forming poroid areas, tough, peeling readily from agar; marginal zone broad, fragile, colorless, appressed-cottony; margin proper colorless, fimbriate; chlamydospores abundant, globose to clavate or irregular, $8-14\times5-8\mu$, rather thinwalled; submerged hyphae $1-4\mu$, clamps abundant; superficial hyphae $1-3\mu$, thick-walled, smooth, little branched; growth at constant temperatures 3.5 cm., 21°; 6.0 cm., 26°; 7.0 cm., 31°; 5.0 cm., 36°; moderately strong reaction with tannic acid medium.

In 14 days mat white, finely nodulose-cottony to velvety-cottony, often with well developed poroid areas over central zone, azonate, tough, peeling readily from agar; poroid areas often producing abundant globose to subglobose, secondary spores, $6-8\times5-6\mu$, thick-walled, hyaline, produced on short branches of superficial hyphae; immature basidia also produced in poroid areas, no mature basidiospores noted; odor faint, mushroom-like.

Test tube cultures. In 4 weeks producing wood colored pores mostly on upper part of slant, rest of mat white, pores containing numerous small secondary spores.

Distinguishing characters. F. fraxinophilus may be distinguished from F. fraxineus by lack of staghorn branches on superficial mycelium and by wood colored pores. F. fraxinophilus may be distinguished from all other Fomes having a white mat by the production of pores in tube cultures and by the small, subglobose secondary spores.

10. FOMES FULVUS Scop. ex. Gill. Type culture: 16870-S. Figures 31-35, 108.

Growth slow to moderately rapid, mat 3.5–5 cm. in 7 days, thin, appressed long-cottony, strongly to faintly zoned, with superficial mycelium orientated toward center, surface about inoculum sometimes covered with scattered patches of compacted, raised, hardened mycelium, which develop into poroid areas, but in other isolates no evidence of poroid areas, in general ochraceous buff to cinnamon buff with compacted, nodulose patches darkening to buckthorn brown; marginal zone greyish white

coarse-cottony; margin proper colorless, even; no secondary spores; immature basidia abundant in poroid areas; submerged hyphae $2-6\mu$, without clamps but with cross-walls, gradually grading into white superficial hyphae with definite hyaline wall, often incrusted with large smooth crystals; brown superficial hyphae $3-4\mu$, heavy walled, darkening in KOH; growth at constant temperatures 4.5 cm., 21°; 5.0 cm., 26°; 4.5 cm., 31°; 2.5 cm., 36°; moderately strong reaction with tannic acid medium.

In 14 days mat 8–9 cm., appearance same as at 7 days, poroid areas more numerous giving nodulose to pulverulent appearance to mat, basic portion ochraceous buff to cinnamon buff, poroid places buckthorn brown or darker; secondary spores none; mature basidia clavate to short cylindric, $10-15\times3.5\mu$, usually forming definite hymenial layer containing narrow paraphyses extending up to 20μ and occasionally brown setae; basidiospores ellipsoid to allantoid, slightly flattened on one side, $3-4\times2-3\mu$; odorless.

Test tube cultures. Mat thin, appressed, with hard appearing surface or more cottony, ochraceous buff to antimony yellow and yellow buff with poroid areas or remaining undifferentiated.

Distinguishing characters. F. fulvus may be readily identified by production of fruiting structures in culture; when these are lacking, however, growth rate and temperature relations must be relied upon to separate it from other rapid growing Fomes species.

11. FOMES GEOTROPUS Cooke. Type cultures: FP-55521-S, FP-55558-S Figures 36-38, 109.

Growth very rapid, mat 7 cm. in 4 days, white, closely appressed cottony to loosely cottony, homogeneous, very fragile, azonate, closely adhering to agar; secondary spores none; immature basidia at times numerous, often lacking; submerged hyphae small, $2-3(-4)\mu$, without clamps; superficial hyphae up to 7μ , without clamps, staining deeply with eosin, often incrusted; growth at constant temperatures in 7 days, 9.0 cm., 21°; 15 cm., 26°; 15 cm., 31°; 9 cm., 36°; faint reaction with tannic acid medium.

In 14 days mat white, either closely appressed, pulverulent, homogeneous, with tendency to form sporophores, or loosely cottony, tufted, without sporophores; mature basidia abundant; basidiospores ellipsoid, $4-5\times 3-4\mu$; odor faint, mushroom-like.

Test tube cultures. In 4 weeks, white, appressed or loosely cottony usually portion on agar producing yellowish areas containing crystalline material.

Distinguishing characters. F. geotropus may be distinguished from all

other Fomes species that produce a white mat in culture on growth rate alone, forming a mat 10-12 cm. in diameter in 7 days at room temperature.

12. FOMES IGNIARIUS (L. ex Fries) Gill. Type cultures: 17171-S, 17355-S. Figures 39-41, 110.

Growth slow, mat 2–3 cm. in 7 days, raised, compacted woolly to felty or loosely felty-cottony, at times nodulose or ridged, definitely two-zoned, central zone ochraceous buff, through clay color to buckthorn and Dresden brown, marginal zone narrow to broad, chalky white; margin proper colorless to white, somewhat fimbriate; submerged hyphae $2-5\mu$, without clamps; superficial hyphae of two kinds, either colorless up to 7μ , with slightly thickened hyaline wall and deeply staining contents, or colored, with thick hyaline wall, non-staining, $2-4\mu$, with few cross-walls; growth at constant temperatures 3.5 cm., 21° ; 4.2 cm., 26° ; 3.1 cm., 31° ; 1.5 cm., 36° ; strong reaction with tannic acid medium.

In 14 days mat 5–6 cm., raised, loosely felty to compacted fine-woolly, two-zoned nature less pronounced, central portion yellow ochre to buckthorn brown and often as dark as Sudan brown and antique brown; color often toned down by whitish to yellowish superficial covering, tough, peeling readily from agar in thick felted sheets leaving whitish film attached to agar; secondary spores questionable, occasional globose to irregular thick-walled chlamydospore-like bodies produced up to 30μ in diameter; odorless.

Test tube cultures. Fruiting pad formed on agar slant, usually fine woolly, warm buff to ochraceous buff, rest of mat buckthorn brown to Dresden brown, often with alternating light and dark bands on agar cylinder.

Distinguishing characters. It is possible to confuse F. igniarius with certain other colored species such as F. robustus, F. rimosus, F. torulosus and F. densus. However, F. igniarius possesses a more distinctly two-zoned nature and peels more readily from the agar leaving a whitish film attached. It differs from F. igniarius var. laevigatus by growing at a much slower rate and in possessing no odor.

13. FOMES IGNIARIUS var. LAEVIGATUS Fries. Overh. Type culture: 17359-S. Figures 42, 43, 111.

Growth rapid, mat 4.5-6 cm. in 7 days, usually two-zoned, central zone closely compacted, felty to felty-cottony, moderately thick, homogeneous, peeling evenly and cleanly from underlying agar, ochraceous tawny to buckthorn brown, marginal zone appressed cottony to woolly, changing from white on outer limits to yellowish on inner, adhering to agar, thin; margin proper white, thin, scraggly, coarsely fimbriate; sub-

merged hyphae, $3-7\mu$, cross-walls common, clamps none or rare; superficial hyphae of two kinds, white, staining in eosin, with moderately thick hyaline wall $3-7\mu$, or brown, thick-walled, non-staining, $1.5-3(-4)\mu$, little branched and with few cross-walls; growth at constant temperatures 4.7 cm., 21° ; 6.5 cm., 26° ; 6.0 cm., 31° ; 2.5 cm., 36° ; strong reaction with tannic acid medium.

In 14 days mat homogeneous, evenly ochraceous tawny to buckthorn brown, closely compacted, appressed, nodulose, felty to felty-cottony, separating cleanly from underlying agar in thick felted sheets; odor sweetish, resembling wintergreen, most pronounced when cultures are grown in the dark.

Test tube cultures. In 4 weeks, mat felty-cottony, evenly buckthorn brown to Dresden brown, no pad formed.

Distinguishing characters. F. igniarius var. laevigatus may be distinguished from F. igniarius by its more rapid rate of growth and by its characteristic odor when grown in the dark.

14. FOMES IGNIARIUS VAI. NIGRICANS Fries.

The various isolates designated *F. igniarius* var. *nigricans* showed no close agreement as to cultural characters. Some were readily recognizable as *F. igniarius* var. *laevigatus* while others differed but slightly from the typical *igniarius*. Until a study can be made of more isolates of the resupinate form of *igniarius* called the *nigricans* variety, it will be impossible to state whether or not a distinct species exists recognizable by cultural characteristics.

15. **Fomes igniarius** var. **populinus** (Neuman) n. comb. Type culture: 16431-S. Figures 44-47, 112.

Growth extremely slow, mat 1–2 cm. in 7 days, variable, compacted, appressed vinaceous brown and haematite red to Brussels brown and raw umber, individual isolates either solidly one color or a combination of several, usually with a fairly distinct, narrow, white to yellowish border; surface of mat covered with a thin to heavy, short-velvety to downy, superficial covering which may be same color as mat proper or somewhat lighter; margin proper narrow, colorless, very closely appressed, even; mat usually producing heavy brown diffusion zone in ordinary malt agar; globose to ellipsoid or irregular-shaped swellings fairly common in some cultures on colored hyphae; hyphae in general show a gradual gradation from submerged thin-walled colorless type to brown superficial type, submerged $3-4(-7)\mu$, thin-walled, many cross-walls, much branched, often broken up into short lengths by empty cells, older hyphae yellowish in ap-

pearance, non-staining with ellipsoid swellings, empty hyaline hyphae also common, often showing constrictions at cross-walls; on surface of cultures short lengths of dark, thick-walled hyphae common in some isolations rare in others, $3-4\mu$; growth at constant temperatures 1.5 cm., 21° ; 2.0 cm., 26° ; 1.0 cm., 31° ; trace 36° ; strong reaction with tannic acid medium.

In 14 days mat 1.5-4 cm., variable, closely appressed, compacted, raw sepia to Brussels brown with at times a distinct lighter colored marginal zone, at times appearing much as reduced forms of F. igniarius with pronounced two-zoned mat; odor very pronounced, characteristic, sweet, agreeable.

Test tube cultures. Poor growth in 4 weeks, mat much appressed, dark, with strong diffusion zone in agar.

Distinguishing characters. On growth rate alone F. igniarius var. populinus can be confused only with F. robustus var. tsugina and possibly with F. conchatus. Odor is sufficient to distinguish it from the ones mentioned while resemblance to the typical igniarius will help to distinguish the individual isolations that grow at a faster rate than the usual Populus form.

16. FOMES JUNIPERINUS (Schrenk) Sacc. & Sydow Description based on F-3765. Figures 48, 49.

Growth extremely slow, mat 1 cm. in 7 days, homogeneous, appressed, fine woolly-cottony, olive buff to deep olive buff over inoculum, white at margin, usually producing strong diffusion zone in agar; submerged hyphae and colorless superficial hyphae $2-4\mu$, clamps abundant; yellow superficial hyphae $2-3\mu$, non-staining, darkening in KOH, thick-walled and with clamps; constant temperature studies unsatisfactory as fungus makes little measurable growth in 7 days, growth checked above 31° ; strong reaction with tannic acid medium.

In 14 days mat 1.5 cm., center olive buff to deep olive buff, marginal portions white or yellowish; odorless.

Test tube cultures. In 4 weeks producing a fine woolly to velvety, olive buff to antimony yellow mat, fragile, homogeneous.

Distinguishing characters. Fomes juniperinus as here described may be separated readily from all other Fomes producing clamps by its fine woolly mat, by its olive buff color, and by its slow rate of growth.

17. FOMES LOBATUS (Schw.) Cooke. Type culture: FP-57032-S. Figures 50-53, 113.

Growth slow, mat 2.5-4 cm. in 7 days, definitely two-zoned, central zone appressed, white to yellowish, compacted, often wrinkled, pulveru-

lent to pruinose; marginal zone white, loosely cottony with radiating growth lines in sharp contrast to amorphous central zone; margin proper colorless to faintly white, appressed, fimbriate; submerged hyphae 2–4 $(-5)\mu$, clamps common; superficial hyphae 2–3 μ , hyaline, non-staining; cuticular cells common in central zone; staghorn branches on surface hyphae, hyaline, readily broken off; growth at constant temperatures 3.5 cm., 21°; 5.0 cm., 26°; 4.0 cm., 31°; 1.0 cm., 36°; strong reaction with tannic acid medium.

49

In 14 days mat 7–8 cm.; central zone making up most of mat, appressed, much compacted, often wrinkled and furrowed, pulverulent to pruinose or at times covered with scattered patches of short cottony mycelium, solidly avellaneous to buffy brown or only somewhat yellowish in scattered areas that are usually grouped into one or more concentric rings; marginal zone white, cottony; cuticular cells very abundant in central zone; odor variable, faint to prominent, difficult to describe.

Test tube cultures. In 4 weeks mat changing from white to yellowish or cinnamon drab on slant, roughened, granular, pulverulent, the portion on agar cylinder irregularly nodulose, cottony, often yellowed with granular masses containing crystals. Deepest colors reached in 8 weeks cinnamon drab to buffy brown.

Distinguishing characters. Fomes lobatus may be distinguished from all other Fomes species producing staghorn branches on superficial mycelium by the dense compacted yellowish to drab central zone containing cuticular cells and by the cottony radiating, white, marginal zone.

18. FOMES MARMORATUS (Berk. & Curt.) Cooke. Type Culture: FP-57058-S. Figures 54-57, 114.

Growth slow, mat 3–4 cm. in 7 days, appressed, thin, faintly to prominently zonate, somewhat cottony with radiating growth lines, uniformly faintly white to somewhat ochraceous or deepening to cinnamon buff and cinnamon, usually with appressed, wrinkled, compacted area about inoculum, cinnamon buff to sayal brown, either localized or extensive, pulverulent, whitish in spots; oidia rare to fairly abundant, in chains of few to several, thin-walled, 3–5 μ in diameter and in lengths up to 35 μ ; cuticular cells abundant in compacted areas, thin-walled, colored when mature, up to 25 μ diameter; submerged hyphae, 2–4(–6) μ , clamps abundant; superficial hyphae uniformly 2–3(–4) μ , thick-walled, colored or hyaline; growth at constant temperatures 3.8 cm., 21°; 5.7 cm., 26°; 6.5 cm., 31°; 4.6 cm., 36°; moderately strong reaction with tannic acid medium.

In 14 days mat 7-8 cm., appressed, thin, zonate, cottony, faintly white through pinkish buff to cinnamon buff and cinnamon, either evenly

colored or deeper colors confined to irregular patches, center wrinkled, appressed pulverulent, cinnamon buff to sayal brown; no distinct odor.

Test tube cultures. In 4 weeks upper part of mat appressed, pulverulent, compacted, Dresden brown to raw umber, separated from white or smoky portion on agar cylinder by a dark, raised line.

Distinguishing characters. F. marmoratus is the only one of the brown colored species of Fomes to produce cuticular bodies in culture. Presence of oidia also very characteristic.

19. FOMES MELIAE (Underwood) Murrill. Description based on FP-50236-R. Figures 58-60, 115.

Growth slow, mat 3.5–5 cm. in 7 days, thick, homogeneous, azonate, white, fine velvety-cottony; margin white to colorless, coarsely fimbriate; chlamydospores none or few produced in 7 days, lemon-shaped or ellipsoid $10-15\times6-9\mu$; submerged hyphae $2-4\mu$, clamps abundant; superficial hyphae, $2-3(-4)\mu$, hyaline, non-staining; growth at constant temperatures 3.5 cm., 21° ; 4.5 cm., 26° ; 7.0 cm., 36° ; 8.0 cm., 36° ; no reaction with tannic acid medium.

Explanation of figures 54-98

Figs. 54-57. F. marmoratus. 54, Submerged hyphae. 55, Superficial hypha. 56, Oidia. 57, Cuticular cells.

Figs. 58-60. F. meliae. 58, Submerged hyphae. 59, Superficial hypha. 60, Chlamydospores.

Figs. 61-63. F. officinalis. 61, Superficial hypha. 62, Submerged hyphae. 63, Chlamydospores.

Fig. 64. F. ohiensis. Hyphae.

Figs. 65-67. F. Pini. 65, Submerged hypha. 66, Superficial hypha. 67, Hyphal swellings.

Figs. 68-71. F. pinicola. 68, Submerged hyphae. 69, Superficial hypha. 70, Chlamydospores. 71, Basidiospores.

Figs. 72, 73. F. rimosus. 72, Submerged hyphae. 73, Superficial hypha.

Figs. 74, 75. F. robustus. 74, Submerged hyphae. 75, Superficial hypha.

Figs. 76–80. F. roseus. 76, Submerged hyphae. 77, Superficial hypha. 78, Chlamydospores. 79, Basidia. 80, Basidiospores.

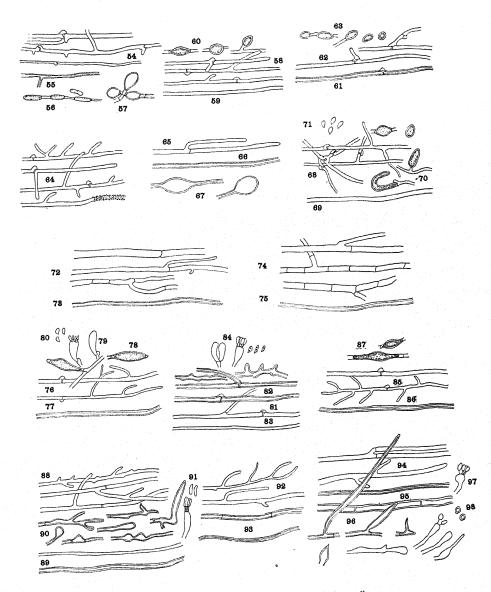
Figs. 81–84. F. scutellatus. 81, Submerged hypha. 82, Superficial hyphae. 83, Smaller superficial hypha. 84, Basidia and basidiospores.

Figs. 85-87. F. subroseus. 85, Submerged hyphae. 86, Superficial hypha. 87, Chlamydospores.

Figs. 88-91. F. tenuis. 88, Submerged hyphae. 89, Superficial hyphae. 90, Irregular hyphal lengths and setae. 91, Basidia and basidiospores.

Figs. 92, 93. F. torulosus. 92, Submerged hyphae. 93, Superficial hyphae.

Figs. 94-98. Sterile Fomes. 94, Submerged hyphae. 95, Superficial hypha. 96, Setae from surface of mat. 97, Basidia. 98, Basidiospores.



Figs. 54-98. (See opposite page for legend)

In 14 days mat 8 cm. or more, white, finely velvety-cottony, homogeneous, azonate, forming a heavy gelatinous film on agar; chlamydospores more common; strong mushroom-like odor.

Test tube cultures. In 4 weeks mat white, homogeneous, at times producing fruiting body and mature spores.

Distinguishing characters. F. meliae differs from all other Fomes species here reported except F. geotropus in that its optimum temperature is around 36°, and by the tough, gelatinous nature of the film formed on the surface of the agar.

20. FOMES OFFICINALIS (Vill. ex Fries) Faull. Type culture: F-1276. Figures 61-63, 116.

Growth very slow, mat 1–2 cm. in 7 days, white, raised woolly to woolly-cottony, homogeneous; azonate, fragile; margin colorless to faintly white, narrow to wide, somewhat appressed fimbriate; chlamydospores numerous, globose to ellipsoid 6–15 μ , with irregular shaped ones much larger; submerged hyphae 2–5 μ , clamps abundant; superficial hyphae very similar to submerged hyphae but with slightly thicker walls, 2–5 μ ; growth at constant temperatures 1.0 cm., 21°; 2.2 cm., 26°; 1.5 cm., 31°; 0 cm., 36°; no reaction with tannic acid medium.

In 14 days mat 2–4 cm., white, raised woolly to woolly-cottony, homogeneous, azonate, fragile; chlamydospores more numerous than at 7 days; odorless.

Test tube cultures. In 4 weeks, mat white, nodulose, cottony to floccose on slant, fragile, powdery, rather loosely floccose-cottony on agar cylinder, becoming in time a powdery mass of chlamydospores.

Distinguishing characters. Fomes officinalis may be distinguished from all other species not reacting with tannic acid by the slow rate of growth and the production of chlamydospores.

21. FOMES OHIENSIS (Berk.) Murrill. Description based on FP-52020-S. Figures 64, 117.

Growth very slow, mat 1–2 cm. in 7 days, white or colorless, closely appressed with at times a glazed appearance; margin colorless, even; hyphae essentially of one kind, up to 4μ , with abundant clamps; growth too slow to secure satisfactory data 1–2 cm. in 7 days at 21° and 26°, little or no growth at 31° and 36°; strong reaction with tannic acid medium.

In 14 days mat 2-3 cm., dense, very closely appressed, milky white, sometimes cream colored, finely granular to the eye, central portion at times pulverulent, azonate with at times a marked ring paralleling margin; chlamydospores few or none; not abundant until culture has aged con-

siderably; hyphae about center heavily incrusted; odor faint, mushroom-like.

Test tube cultures. In 4 weeks mat chalky white to cream colored, appressed, pulverulent, compacted, marginal portion on agar cylinder very finely floccose-cottony.

Distinguishing characters. Fomes ohiensis may be distinguished from all other reactors with tannic acid medium by its extremely slow rate of growth and by its white color. F. tenuis bears some resemblance but becomes definitely colored in 14 days, while F. conchatus does not have clamps as does F. ohiensis.

22. FOMES PINI (Thore) Lloyd. Type culture: 17553-S. Figures 65-67, 118.

Growth slow, mat 2–3 cm. in 7 days, cultures divided into two forms, one form producing a loose-cottony, raised mat, yellow to ochraceous buff, the other form producing a thick, felted, appressed mat, ochraceous buff, through antimony yellow to yellow ochre; margin proper even, colorless; submerged hyphae $2.5-4(-5)\mu$, no clamps; superficial hyphae of two kinds, either white, staining heavily in eosin, with moderately thick hyaline walls, or colored, thick-walled, $2.5-4\mu$, often with irregular-shaped swellings which resemble chlamydospores, in KOH the color diffuses readily turning the solution golden-brown; growth at constant temperatures 1.7 cm., 21° ; 2.5 cm., 26° ; 2.0 cm., 31° ; trace, 36° ; moderately strong reaction with tannic acid medium.

In 14 days mat 3-4 cm., two forms persisting, not much change in appearance; increase in number of hyphal swellings; odor faint, musty.

Test tube cultures. In 4 weeks, mat felty-cottony, nodulose, uneven, appressed in spots, cottony pad at times formed on slant, varying from ochraceous buff to yellow ochre and buckthorn brown, pad usually lighter, warm buff to ochraceous buff.

Distinguishing characters. F. Pini may be distinguished from all other colored species of Fomes except F. conchatus by the golden yellow color imparted by yellow superficial hyphae to KOH; however, variations in appearance of mat and temperature relations are sufficient to separate F. Pini from F. conchatus.

23. FOMES PINICOLA (Sw.) Cooke. Type cultures: 16433-S, 15348-S. Figures 68-71, 119.

Growth very variable, mat 3.5-6 cm. in 7 days, either thin and loosely floccose-cottony or rather felty, white, homogeneous; margin thin, colorless or faintly white, coarsely fimbriate; chlamydospores few to numerous, globose to ellipsoid or irregular, $7-12\times5-9\mu$; submerged hyphae

 $2-5\mu$, clamps abundant; superficial hyphae $2-4\mu$, thick-walled, hyaline, without clamps; growth at constant temperatures 4.3 cm., 21°; 6.0 cm., 26°; 7.6 cm., 31°; trace to 1.0 cm., 36°; no reaction with tannic acid medium.

In 14 days mat 7 cm. or more, white, appressed-felty or floccose-cottony to loosely floccose-cottony, forming fairly tough film on agar; submerged hyphae with tendency to break up into irregular shapes not definite enough to be classed as oidia; odor distinct, mushroom-like.

Test tube cultures. In 4 weeks, mat white with tendency to verge toward pink or cream color, very fragile, appressed on slant; finely cottony to floccose-cottony on agar cylinder, some isolates forming fruiting structures.

Distinguishing characters. F. pinicola can be confused with several of the non-reactors on tannic acid media, namely F. meliae, F. subroseus and F. roseus. From F. meliae it may be separated on temperature basis since F. pinicola barely grows at 36°, while F. meliae is near its optimum; from F. subroseus by lack of definite vinaceous color of mat and also different shape of chlamydospore; from F. roseus by faster growth rate.

24. FOMES RIMOSUS Berk. Type culture: FP-57079-S. Figures 72, 73, 120.

Growth slow, mat 2–4 cm. in 7 days, very thin, fragile, appressed velvety-cottony at center, buckthorn brown or darker to finely floccose-cottony at margin, colorless to mustard yellow, blending with color of agar; margin proper narrow to wide, colorless, very closely appressed, even; submerged hyphae variable in size $3-6(-8)\mu$, no clamps; superficial hyphae moderately thick-walled, colored, uniformly $3-4\mu$; growth at constant temperatures 1.5 cm., 21°; 3.6 cm., 26°; 4.5 cm., 31°; 1.5 cm., 36°; faint to moderately strong reaction with tannic acid medium.

In 14 days mat 4–5 cm., appressed, thin, finely floccose-cottony, buckthorn brown over inoculum becoming lighter toward margin until merging into wide colorless marginal zone; or mat thicker, floccose-cottony, with buckthorn brown or mustard yellow central zone and white, broad marginal zone; odorless.

Test tube cultures. In 4 weeks, mat either compacted, felty-cottony or loose cottony, yellow ochre to buckthorn brown, thick, with at times tendency to form shallow poroid areas.

Distinguishing characters. F. rimosus may be distinguished from other slow growing brown forms by possessing a faster growth rate at 31° than F. robustus, F. Pini, F. Calkinsii, F. torulosus and F. igniarius. Also the thick, compacted, crumbly mat formed in tube cultures, definitely separates it from F. robustus, F. Calkinsii and F. torulosus which produce

tough thin films on the agar. The mat does not peel from the agar as does F. igniarius, and the large size of hyphae separates it from all but F. robustus.

25. Fomes robustus Karst. Type culture: 16015-S. Figures 74, 75, 121.

Growth slow, mat 2.5–3.0 cm. in 7 days, cultures showing two distinct forms, one form producing a raised, nodulose, finely felty-cottony, to woolly, azonate mat, antimony yellow to yellow ochre over center gradually shading to white at margin, the other form compacted, appressed, zonate, from buckthorn brown at center to yellow ochre and primuline yellow, with a wide, white, cottony marginal zone; margin proper colorless, narrow, even; submerged hyphae variable in size, $3-6(-7.5)\mu$, no clamps; superficial hyphae $2-4\mu$, thick-walled, yellowish brown rough in outline, darkening in KOH; growth at constant temperatures 2.4 cm., 21°; 3.2 cm., 26°; 3.3 cm., 31°; trace 36°; strong reaction with tannic acid medium.

In 14 days mat 5–6.5 cm., raised form evenly warm buff to buckthorn brown, color heaviest over inoculum; appressed form distinctly zoned, warm buff to buckthorn brown, not evenly colored but at times color distributed in relation to concentric zones; odorless.

Test tube cultures. In 4 weeks no distinction between forms, all isolates with raised, velvety-cottony to finely woolly fruiting pad on slant, buckthorn brown to yellow ochre; on agar cylinder homogeneous, essentially one color, buckthorn brown, tough, peeling readily from agar.

Distinguishing characters. F. robustus cannot be separated from F. Calkinsii with certainty in either Petri cultures or test tube cultures. In general, F. robustus grows at a slightly faster rate, is more vigorous in appearance and is more deeply colored. As far as test tube cultures are concerned, F. robustus, F. Calkinsii, F. densus and F. torulosus are practically identical and exhibit no features of value in identification. Temperature relations help to separate it from F. densus, but F. torulosus is more deeply colored and the submerged hyphae are smaller.

26. FOMES ROBUSTUS var. TSUGINA (Peck) Overh. Type Culture: 16836-S. Figure 122.

Growth very slow, mat 1-2 cm. in 7 days, buckthorn brown to cinnamon brown with a fine, short cottony to woolly, superficial covering, straw yellow to Naples yellow; margin thin, colorless, appressed, fairly broad, even; hyphal characters as for F. robustus; strong reaction with tannic acid medium.

Mat in 14 days 3-4 cm., dark brown as seen from underside of dish,

often producing a diffusion zone of considerable extent in agar, with a thin, cottony to woolly superficial covering, ochraceous buff to yellow ochre, mat proper as viewed through superficial covering dark vinaceous brown; odorless.

Distinguishing characters. On growth rate, color, and reaction to gallic and tannic acids. F. robustus var. tsugina falls into a group with F. conchatus, F. juniperinus, F. igniarius, var. populinus and F. tenuis. It may be distinguished from F. conchatus on general appearance since it does not produce the white, felty, cottony mat during the first 7 days of growth. F. juniperinus is more yellowish and homogeneous than var. tsugina and also produces clamps on submerged hyphae. F. igniarius var. populinus may be separated by its characteristic odor while F. tenuis does not form the dark colored mat proper nor the diffusion zone in the agar.

27. FOMES ROSEUS (Alb. & Schw.) Cooke. Type cultures: Snell 10 and 11. Figures 76–80, 123.

Growth slow, mat 3.5–4.5 cm. in 7 days, white to very slightly pinkish or rose-tinted, appressed, floccose-cottony, with mycelium orientated toward center, often definitely plumose, homogeneous, azonate; chlamydospores few, irregular in shape and size, with fairly thick hyaline wall, up to 40μ in length; submerged hyphae $1.5-3(-4)\mu$, clamps abundant; superficial hyphae similar with heavier walls and deeply staining contents, or more fibrous, non-staining up to 4μ ; growth at constant temperatures 3.5 cm., 21° ; 4.0 cm., 26° ; 4.5 cm., 31° ; 1.5 cm., 36° ; no reaction with tannic acid.

In 14 days mat 7–8 cm., thin, appressed, floccose-cottony, plumose especially near margin, white over entire surface or rose-tinted over inoculum or over major portion; odor distinct, of green apples.

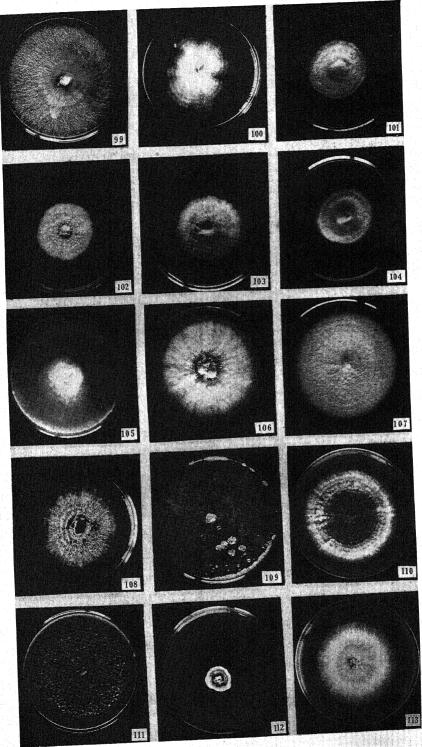
Test tube cultures. In 4 weeks mat thin appressed, with definite plumose appearance from pinkish buff through vinaceous cinnamon to as dark as cinnamon over inoculum, rest of mat white, or with indefinite pink or vinaceous tint, fragile.

Distinguishing characters. F. roseus falls in the same group as F. pinicola, F. meliae and F. subroseus. However, the slower rate of growth at

Explanation of figures 99-113

Mats on malt agar, in diffused light, at room temperature. Age 14 days unless otherwise stated.

Fig. 99. Fomes annosus. 100. F. applanatus. 101. F. Calkinsii. 102. F. conchatus. 103. F. densus. 104. F. Everhartii. 105. F. fomentarius. 106. F. fraxineus. 107. F. fraxinophilus. 108. F. fulvus, age 11 days. 109. F. geotropus. 110. F. igniarius. 111. F. igniarius var. laevigatus. 112. F. igniarius var. populinus. 113. F. lobalus.



Figs. 99-113. (See opposite page for legend)

 31° and the pinkish or vinaceous tints developed in tube cultures definitely separate it from the first two, while Snell's (1928) observation as to growth rate at 31° is the only way to separate it from *F. subroseus*.

28. FOMES SCUTELLATUS (Schw.) Cooke. Type culture: 17039-S. Figures 81-84, 124.

Growth slow, mat 2.5–4 cm. in 7 days, isolates showing considerable variation, either with a prominent, appressed, central zone, cinnamon buff to brownish drab and army brown, with white appressed, granular marginal zone; or mat white, loosely felty-cottony, without any or only slight indication of a colored central zone; margin proper also variable, appressed, colorless, fimbriate to more cottony and white; submerged hyphae, $2-4(-5)\mu$, with clamps or with thick-walls and deeply staining contents, irregularly branched with short, knobbed sections; superficial hyphae from colored central zone, $2-4\mu$, thick-walled, without clamps; growth at constant temperatures 3.1 cm., 21° ; 3.6 cm., 26° ; 1.5 cm., 31° ; 0 cm., 36° ; strong reaction with tannic acid medium.

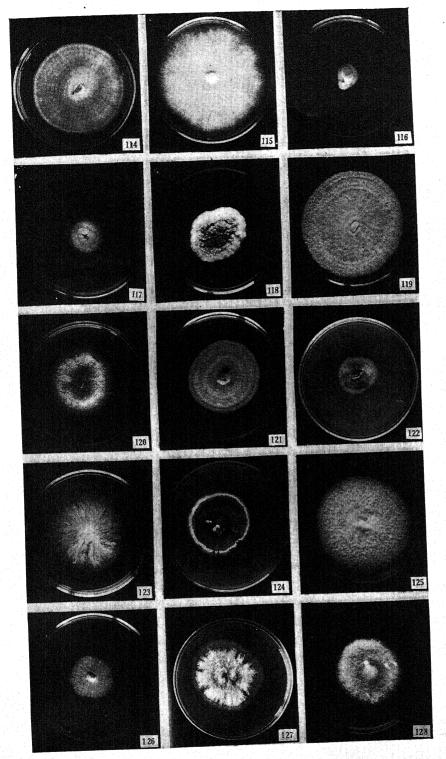
In 14 days mat 5–9 cm., size dependent upon whether mat remains white and felty without producing a central zone or whether it develops an appressed colored central zone, sayal brown, to army brown and dark greyish brown, both forms producing poroid areas on surface containing well developed basidia and spores; basidia clavate; basidiospores variable, allantoid $6-14\times3.5-4\mu$; paraphyses-like organs found in basidial layer; no odor.

Test tube cultures. In 4 weeks mat either remaining white with wood colored or yellowish poroid areas or forming a dark, compacted region on surface of slant, separated from rest by a sharp distinct line, sometimes forming a definite pellicle, with poroid areas developing on colored portion very suggestive of pore surface of F. scutellatus; rest of mat white, homogeneous.

Distinguishing characters. F. scutellatus may appear in several widely differing forms which complicates its identity in culture. If it forms the typical appressed, colored central zone, it may readily be recognized, as no reactor with tannic acid approaches it in appearance; if, however, it remains white and felty, it may superficially resemble F. fraxineus and

Explanation of figures 114-128

Fig. 114. Fomes marmoratus. 115. F. meliae. 116. F. officinalis. 117. F. ohiensis. 118. F. Pini. 119. F. pinicola. 120. F. rimosus. 121. F. robustus. 122. F. robustus var. tsugina. 123. F. roseus, age 11 days. 124. F. scutellatus. 125. F. subroseus, age 11 days. 126. F. tenuis. 127. F. torulosus. 128. Sterile Fomes.



Figs. 114-128. (See opposite page for legend)

F. fraxinophilus, but as it never produces chlamydospores may be readily separated. In test tube cultures, the production of basidia and characteristic allantoid spores coupled with the possible formation of a pellicle, makes it easy to identify.

29. FOMES SUBROSEUS (Weir) Overh. Type cultures: Snell-20, FP-57047-S. Figures 85-87, 125.

Growth fairly rapid, mat 4.5–6 cm. in 7 days, chalky white to pink or rose tinted, fairly thick nodulose-cottony to tufted floccose-cottony or felty, homogeneous, azonate, often with poroid areas; margin wide, colorless, appressed, fimbriate; chlamydospores few, lemon-shaped to elongate, $15-45\times6-9\mu$; submerged hyphae $2-4\mu$, thin-walled, clamps abundant; superficial hyphae with thicker walls, deep staining contents, clamped $2-4\mu$; growth at constant temperatures 4.5 cm., 21° ; 6.0 cm., 26° ; 6.5 cm., 31° ; 2.5 cm., 36° ; no reaction with tannic acid medium.

In 14 days mat appressed to raised, floccose-cottony to tufted floccose-cottony, homogeneous, azonate, white at margin to irregularly light vinaceous fawn or fawn color, often with distinct poroid areas confined to inoculum or covering most of surface; chlamydospores more numerous; mature basidia rare; basidiospores short cylindric, $5-8\times 2-3.5\mu$; odor distinct, that of green apples.

Test tube cultures. In 4 weeks mat on slant either appressed, floccose-cottony, or raised, with pad on upper part of slant; pores when developed pale ochraceous buff; mat faintly pinkish with upper part light vinaceous fawn. In 8 weeks becoming light ochraceous salmon to light vinaceous fawn.

Distinguishing characters. F. subroseus may be distinguished from F. roseus by its much faster rate of growth at 31°.

30. FOMES TENUIS (Karst.) Type culture: 17413-S. Figures 88-91, 126.

Growth slow, mat 1.5–2.0 cm. in 7 days, closely appressed, finely floc-cose-cottony, indeterminate in color, greyish white to somewhat yellowish; margin proper colorless, slightly fimbriate; hyphal swellings common, resembling chlamydospores; submerged hyphae, $2-3(-4)\mu$, no clamps; on older portions of mat much branched and contorted; superficial hyphae up to 4μ . thick-walled, colored, very irregular, often in short lengths with many branches and swellings; growth at constant temperatures 1.5 cm., 21° ; 2.0 cm., 26° ; trace at 31° ; strong reaction with tannic acid.

In 14 days mat 3-4 cm., white to cream or ochraceous buff and cinnamon, appressed, finely woolly to appressed downy, fragile, with at times scattered poroid areas; basidia long, clavate, $4-5.5\mu$ in diameter, with

sterigmata up to 4μ ; spores long, cylindric, slightly curved, $6-8\times 2-3\mu$; superficial hyphae often producing dark brown setae $4-6\mu$ in diameter, in connection with poroid areas; odorless.

Test tube cultures. In 4 weeks mat appressed, compacted, yellowish to ochraceous buff, with heavy poroid areas on slant. In 8 weeks darkest colors sayal brown to cinnamon brown.

Distinguishing characters. Of the slow growing Fomes species producing a brown zone with tannic acid media, F. tenuis may be confused with F. conchatus, F. ohiensis and F. robustus var. tsugina. However, F. ohiensis produces abundant clamps, while F. conchatus is more raised, felty-cottony, and color of superficial hyphae will diffuse in KOH, while F. robustus var. tsugina is more deeply colored and has larger hyphae.

31. FOMES TORULOSUS (Pers.) Lloyd. Description based on FP-50278-R. Figures 92, 93, 127.

Growth slow, mat 2.5–4 cm. in 7 days, dense, felty-cottony to woolly, faintly to strongly zonate, color homogeneous, very slightly pale yellow at margin to yellow ochre and buckthorn brown at center; margin colorless, fairly broad, even; submerged hyphae $2-4\mu$, no clamps; superficial hyphae, $3-4\mu$, brown, thick-walled; growth at constant temperatures 2.0 cm., 21°; 3.5 cm., 26°; 3.5 cm., 31°; trace 36°; strong reaction with tannic acid medium.

In 14 days mat 5–7 cm., center dense, felty-cottony, marginal portions more appressed cottony, zonate, antimony yellow to raw sienna; odorless.

Test tube cultures. In 4 weeks mat felty cottony on agar cylinder to loose cottony on slant, often forming loose cottony pad on slant, color homogeneous, between yellow ochre and buckthorn brown, forming a tough film on agar.

Distinguishing characters. F. torulosus resembles quite closely several of the yellow to brown species of Fomes in its cultural characteristics. In general, F. torulosus is uniformly darker, buckthorn brown, while F. robustus, F. Calkinsii, F. rimosus, F. densus and F. igniarius are lighter in color and possess distinct marginal zones.

32. Sterile fomes Type culture: 17352-S. Figures, 94-98, 128.

Growth slow, mat 2–3 cm. in 7 days, white, raised, loosely cottony, fragile; margin white, cottony, fimbriate; submerged hyphae 3–6 μ , thinwalled, no clamps; superficial hyphae small, thick-walled, non-staining, 1.5–3 μ ; growth at constant temperatures 3.0 cm., 21°; 3.0 cm., 26°; 2.0 cm., 31°; trace 36°; strong reaction with tannic acid medium.

In 14 days mat 5-6 cm., white to cream buff or yellowish, raised,

loosely cottony, fragile with scattered yellowish patches, usually containing immature basidia associated with setae and slender paraphyses-like organs; surface of culture producing numerous long setae, readily visible under low-power of microscope and turning reddish when touched with KOH; basidia few to rather numerous, clavate or subglobose, up to 8μ diameter, 2- or 4-spored; spores hyaline, globose to ellipsoid, up to 8μ diameter; setae $5-8\mu$ diameter, projecting up to 25μ in hymenial layer, on surface up to 130μ ; odorless.

Test tube cultures. Mat appressed, yellowish at margin to antimony yellow where best developed, usually producing a large irregular shaped sporophore on slant; poroid areas in cross section show an agglutinated, yellowish mass, without basidia and with numerous short setae lining tubes; no functional basidia seen in abortive sporophores produced in tube cultures.

Distinguishing characters. The sterile fungus on Betula may be distinguished in culture by its light yellowish color, by the long setae on surface which turn reddish in KOH, and by the abortive sporophore produced in tube cultures.

KEY TO SPECIES OF FOMES CULTURED ON MALT AGAR

I and times compared to	
Mat white, often varying from faintly white to chalky white, rose colored, or at times somewhat	
group colored (14 days)	
Mot colored wellow to brown (14 days)	
1. Clamp connections present	
Clause connections absent	
2. Forming brown zone with tannic acid medium	
Not forming brown zone with tannic acid medium	
2. County constar than 3 cm in 7 days at 26° C in dark	
Growth less than 3 cm in 7 days at 26°C in dark	
4 With stacham branches on the superficial mycelium	
With out stachorn branches on the superficial mycelium	
5 Chlamydospores present: fruiting readily in test tube cultures, the pore surfaces vinaceous.	
F. Jaxineus	
Chlamydospores not produced; not fruiting readily; cuticular bodies present in mats 14 days	
old6	
6. Compacted central zone white or cream colored; marginal zone usually appressed colorless.	
F. appianatus	
Compacted central zone yellow to avellaneous or buffy brown; marginal zone usually white,	
cottony, radiating	
7. Pores almost always produced in tube cultures; chlamydospores numerous, of two kinds	
F. fraxinophilus	
Pores never produced in tube cultures; chlamydospores very rare, usually absent	
F. fomentarius	
8. Growth 1-3 cm. in seven days at 26° C	
Growth greater than 3 cm. in seven days at 26° C	
9. Forming a gelatinous layer on agar; optimum about 36° C, forming a mat 8 cm. in diameter	
at that temperature	
Not forming a gelatinous layer on agar, growth inhibited or stopped at 36° C	

10.	Remaining white in cultures 14 days old; test tube cultures also white or slightly yellowish at 4 weeks
	Becoming rose tinted or pinkish in 14 days; mats in test tubes becoming as dark as vinaceous- cinnamon or cinnamon
11.	Growth averaging 6.5 cm. in 7 days at 31° C. (dark)
	Growth averaging 4.5 cm. in 7 days at 31° C. (dark) F. roseus
12.	Producing numerous conidia on subglobose coniophores
	Not producing conidia
13.	Growth at 26° C. more than 6 cm. in 7 days, averaging 15 cm F. geotropus
	Growth at 26° C. less than 6 cm. in 7 days
1.4	Mat raised, felty-cottony, at times forming rather definite dark colored mat proper; growth
14.	
	about 2 cm. in 7 days
	Mat appressed, thin, downy; hyphal swellings common; often producing basidia and spores
	in tube cultures; growth 2 cm. in 7 days
	Mat white, felted, averaging 4 cm. in 7 days; usually forming sporophore in tube cultures.
15.	Clamps present
	Clamps absent
16	Growth slow, less than 2 cm. in 7 days at 26°; mat not producing diffusion zone in agar; color
10.	olive buff
	Growth more rapid, more than 3 cm. in 7 days at 26°; mat producing diffusion zone in agar,
	not yellowish in color
	not yellowish in color.
17.	Growth entirely inhibited at 36°; no cuticular cells formed
	Growth slight to vigorous at 36° (1 cm. or more in 7 days); cuticular cells formed 19
18.	Growth 6 cm. in diameter in 7 days at 31°; never fruiting in culture; entire surface of mat
	colored in tube cultures; thick-walled hyphae uniform, 1-4 μ
	Growth 1.5 cm. in diameter in 7 days at 31°; usually fruiting in culture; test tube cultures
	either entirely white or with colored portion confined to upper part; thick-walled hyphae
	often with short irregular knobs and branches
19	Good growth at 36°, 4 cm. or more; oidia present; mat not divided into definite central and
	marginal zones
	Slight growth at 36°, 1-2 cm.; only central zone colored; no spores of any kind produced.
	F. lobatus
20	Growth 5 cm. or greater in 7 days at 26°.
20.	Growth I sest than 5 cm, in 7 days at 26°
0.1	Mat tough, felted, two-zoned at 7 days, when old peeling readily from agar; odor of winter-
21.	Mat tough, felted, two-zoned at 7 days, when old peeling readily from agar, odor of white-
	green F. igniarius var. laevigatus
	Mat thin, short-cottony, homogeneous, evenly colored; not peeling readily from agar
	F. fulvus
22.	Yellow of colored portion of mat diffusing readily in KOH
	Yellow of colored portion of mat not diffusing in KOH24
23.	On hardwoods only; growth practically stopped at 31°
	On coniferous woods; growth averaging 2 cm. at 31°; hyphal swellings commonF. Pini
24.	Growth slow, forming a mat 2 cm. or less in 7 days at 26°; color diffusing at times from mat
	into agar; mat proper dark
	Growth more rapid than 2 cm. in 7 days at 26° or if 2 cm. not forming dark mat proper or
	diffusion zone in agar
25	Mat proper reddish-brown; superficial growth thin; usually on Tsuga; no odor
LJ.	Wat proper reddish-brown, superficial growth thin, usually on 1 suga, no odor
	Mat proper dark; superficial growth thin to fairly dense, often with a definite border; odor
	wat proper dark; supernotal growth that to fairly dense, often with a definite border, odor
	pronounced sweetish; only on Populus F. igniarius var. populinus
	Mat thin, homogeneous, not forming dark mat proper; mat ochraceous buff to cinnamon;
	no odor

from agar in a cle Mat more woolly,	two-zoned, center colored, marginal zone white; when 14 days old peeling can sheet leaving whitish film attached
fruiting pad nor	pinia; mat thin and appressed in light; test tube cultures not forming a forming a tough mat on agar
Found on a variety	of hosts; forming definite fruiting pads on malt agar in test tubes or form-
28. In light usually fo	rming a dark mat proper on agar; superficial covering silky, often with mat when 14 days old turning vinaceous when rubbed with KOH; on oak.
In light usually not	F. Everhartii t forming a dark mat proper, or if so, superficial covering without greenish ly to woolly-cottony
29. Growth at 31° in d	ark never as great as 4 cm. in 7 days, very slight or no growth at 36°30 ark more than 4 cm. in 7 days; fair growth, 1–2 cm., at 36°; mat in 14 days
never darker th	an primuline yellow; superficial covering turning reddish-brown when OH
areas, sterile spo	surface of culture; basidia and basidiospores often produced in scattered prophore usually formed in tube cultures
Not fruiting in cul 31. Hyphae large, up	ture; never producing basidia and setae
Hyphae smaller, r white margin	arely larger than 4μ ; mats usually darker in color and lacking a definite

GENERAL DISCUSSION

Macroscopic characters. In the case of fungi in culture, three possibilities suggest themselves in making separations between groups or between individual species within a group, namely: macroscopic features, or those gross differences in color, texture of mat and the like which are readily visible to the naked eye; microscopic characters, or in reality the actual structural characters as revealed by suitable magnification and staining; and lastly the little known differences which may be classified under physiological reactions.

A brief review of the suggested macroscopic characters, as originally stated by Long and Harsch and further studied by Fritz shows that the following have been considered as being of special importance:—rapidity

³ In general F. robustus and F. Calkinsii resemble each other too closely to be separated on basis of description alone. Certain differences, however, do exist which enable one acquainted at all with the two species in culture to distinguish them. The F. robustus form on Betula is particularly distinct but the form on oak resembles F. Calkinsii to the extent that one is justified in doubting that any distinction should be made between the two species. F. robustus, however, grows at a slightly faster rate, produces a more vigorous mat, and is more strongly colored. In cultures kept in the dark these distinctions are more apparent as F. Calkinsii has a tendency to remain pale and delicate while F. robustus becomes colored and forms a vigorous woolly mat. Even at the best, however, these differences are in degree rather than on specific points.

of growth; color of aerial and submerged mycelium; character of mat as to texture, form, etc.; staining and discolorations of the agar; and the comparative rates of growth between aerial and submerged hyphae. An attempt will now be made to evaluate these suggested criteria in light of their helpfulness in distinguishing between different species of *Fomes*.

In a general survey of any considerable number of fungi in culture probably the most apparent differences between species would be variations in color. Mycelial mats of *Fomes* species vary from colorless or pure white to all shades of yellow and brown. Usually mats that are inherently colorless or white will remain that way no matter how long they are grown, while those becoming colored will at times start as white mycelial patches later acquiring a characteristic color. Usually this color will develop in a definite period of time. This suggests the division of the species of *Fomes* into a white or colorless section and a colored section, meaning by colored some shade of yellow or brown, allowing a definite time limit, say fourteen days, for the cultures to develop. This procedure separates the species quite satisfactorily, but leaves a minimum number of species which are somewhat indefinite in regard to color and which for this reason must be included in both arms of the key.

After color, rapidity of growth, expressed in colony diameter in a definite period of time, offers most promise for identification purposes. The different species of *Fomes* show growth rates with considerable variations, which when correlated with color give valuable information as to identity. However, since room temperature measurements may show much variation constant temperature measurements are to be preferred.

Texture and type of mat produced offer valuable aids in classification of species. As little can be gained by a multiplicity of terms, Long and Harsch's original list has been followed with few additions. This list has been given under *Description of cultures*. After a little practice one becomes quite proficient in classifying the different cultures under the headings given.

Other suggested characters, such as marginal features, discolorations of the agar, distinctions between aerial and submerged hyphae and the like are too vague to be of much value as far as separation of *Fomes* species is concerned.

Microscopic characters. As reported by several workers the list of important microscopic characters includes: septations, branching, size and color of hyphae, presence or absence of clamp connections, polymorphism in spore formation and possibly number and kind of crystals produced in the medium as a result of the metabolic activities of the fungus. In a study of any group of fungi one would hardly expect that the various

microscopic characters would all be of the same importance, and it is quite possible that the value of the different characters varies from group to group. With this in mind an attempt was made to evaluate these characters in relation to the identification of the species of *Fomes* in culture.

Clamp connections with very few exceptions are either present in sufficient numbers as to be readily seen in a microscopic examination or are entirely absent. This makes entirely feasible a division of all species into those with clamps and those without clamps. Appreciable differences in type of clamp produced were not observed although some variation is apparent.

The production of secondary spores in culture adds another possible criterion for the separation of species. These secondary spores may be any one of three types. If, as in *Fomes annosus*, they are produced on definite modifications of the usual hyphal structure, they are designated as *conidia*. If they occur as pyriform or globose inflations of ordinary hyphal cells, produced terminally or intercalary, they are designated as *chlamydospores*. In one species, secondary spores of elongated form (oblong or short cylindric) have been noted. They are regarded as *oidia*. The production of spores varies somewhat with different strains of a given species and with changes in environmental factors. They may, however, be regarded as reliable criteria for purposes of identification, especially when correlated with other factors.

Other microscopic criteria of value for supplementary or correlative information include: presence or absence of staghorn branching; hyphal swellings of various kinds; setae on surface of cultures or in connection with hymenial layers, incrustations of the hyphae; presence or absence of cuticular or vesicular cells; and production of typical basidia and basidiospores.

Hyphal sizes are of little value. In general very little variation occurs between the different species, and what differences do occur are not distinct enough to be reliable. Type of branching is also an uncertain criterion as, although differences in branching do occur, these differences are difficult to describe and apt to be disturbed in the preparation of the specimens for examination. Differences in type of crystals produced are also elusive details which offer but little promise in the separation of the *Fomes* species here reported.

Response to light. The effect of the intensity of light on the form and coloration of the mats in cultures were also studied to considerable extent. In general, light has a suppressing effect on the mycelium, which is probably to be expected, and also influences the development of color. A certain amount of light is necessary for the best development of color and

cultures grown for purposes of identification are best treated when exposed to moderately strong diffused light. Growth rate varies considerably as not all species react the same to light. In the dark, the mass of mycelium produced is apt to remain relatively undifferentiated and for this reason furnish few characters of value in identification.

Temperature relations. All cultures studied were subjected to constant temperature treatment at temperatures of 21°, 26°, 31° and 36° C. These temperatures were chosen as a matter of convenience and are ones which could be most easily maintained at the time the work was carried on. The treatment of cultures during the course of constant temperature experimentation has been given under *Materials and methods*.

Each individual isolate reacts in a characteristic way as far as growth rate is concerned at a given temperature. While each isolate of a given species maintains its own constant rate of growth, the range expected for any species may be expressed within certain limits. The growth rates given for a species at a particular temperature will be the average of the different isolates.

No attempt was made to separate species into low, medium, or high temperature groups, although this can readily be done from descriptions of individual species. Most cultures of *Fomes* show a preference for temperatures between 25 and 30° C., with few able to grow vigorously at 36° C.

At higher temperatures, individual differences in strains or isolates become most apparent. Also slight variations in moisture and experimental handling produce the greatest chances for possible error.

Since intensity of light made considerable difference in colony diameter in a given time, cultures grown under constant temperature conditions, in dark, cannot be compared with cultures kept in light under same temperature conditions.

Reactions with special media. Bavendamm's procedure for detection of white rot fungi and brown rot fungi described under Materials and methods offers a simple means for the classification under these two heads. The brown diffusion zone produced as result of reaction with tannic and gallic acid seems constant for each species. Tannic acid is to be preferred as it turns malt agar white, against which the colored diffusion zone shows up to best advantage.

SUMMARY

- 1. Thirty-one species of *Fomes* were studied in detail as to their cultural characteristics.
- 2. The different species of *Fomes* in culture produce distinct characteristics, which makes their identification fairly certain.

3. The reaction of each species to the culture medium, if conditions remain constant, is distinct and invariable within certain limits. Variations do exist within a given species, these variations being greater in some species than in others.

4. Individual isolates of a given species retain their peculiarities for indefinite periods in culture. There appears to be no sharp change in reaction at any time and individual strains can be depended upon to

remain constant.

5. There is no difference between cultures of the same individual prepared from rot or from the sporophore.

6. Macroscopic features of value in the identification of Fomes species in order of importance are: color of mat; rate of growth as given in terms of diameter of colony at some definite time interval; texture of mat and production of colored zones; and odor may at times be distinctive.

7. Microscopic features of value in the identification of Fomes species in order of importance are: presence or absence of clamp connections; production of secondary spores; existence of supplementary structures such as cuticular bodies, staghorn branches, hyphal swellings, etc.; and hyphal sizes.

8. Most Fomes species in culture show a decided response to light evidenced by change in texture of mat, color, and difference in rate of growth. The amount of change depends upon intensity of illumination.

9. The species of Fomes differ as to minimum, optimum and maximum temperatures required for growth.

10. Malt agar and potato-dextrose agar are the most suitable media

for the culturing of the different species of Fomes.

11. Little supplementary data of use in identification can be secured by culturing the Fomes species on a wide variety of agars.

12. Tannic and gallic acids when added in 0.5 per cent concentration to regular malt agar furnishes a fairly positive means of distinguishing between white-rot and brown-rot fungi.

13. Cultural studies of fungi are valuable not only in the diagnosis of the cause of decay but also in ordinary taxonomic work in distinguishing between species closely related in external form. Also in distinguishing abnormal or aborted forms of the fungus.

DIVISION OF FOREST PATHOLOGY, BUREAU OF PLANT INDUSTRY, WASHINGTON, D. C.

Literature cited

- Bavendamm, W. 1928. Ueber das Vorkommen und den Nachweis von Oxydasen bei Holzzerstorenden Pilzen. Zeitschr. f. Pflanzenkrank. u. Schutz. 38: 257–276.
- Baxter, D. V. 1924. Fomes fraxineus in culture. Papers. Mich. Acad. Science. 4: 55-66.
- ______. 1932. Some resupinate polypores from the region of the Great Lakes. V. Papers. Mich. Acad. Science. 19: 305-332.
- Cartwright, K. St. G. 1929. Notes on basidiomycetes grown in pure culture.
 Trans. Brit. Mycol. Soc. 14: 300-305.
- and Findlay, W. P. K. 1934. Studies in the physiology of wood-destroying fungi II. Temperature and rate of growth. Ann. Bot. 48: 481-495.
- Faull, J. H. 1916. Fomes officinalis (Vill.) a timber-destroying fungus. Trans. Roy. Can. Inst. 11: 185-209.
- Fritz, C. W. 1923. Cultural criteria for the distinction of wood-destroying fungi. Trans. Roy. Soc. Canada. 1923. Sec. V. 191–288.
- Humphrey, C. J. and Siggers, P. V. 1933. Temperature relations of wood-destroying fungi. Jour. Agr. Res. 47: 987-1008.
- Long, W. H. and Harsch, R. M. 1918. Pure cultures of wood-rotting fungi on artificial media. Jour. Agr. Res. 12: 33-82.
- Mounce, Irene. 1929. Studies in forest pathology. II. The biology of Fomes pinicola. Dom. Can. Dept. Agr. Bull. New Series. 111.
- Sluzalis, L. L. 1933. Cultural characteristics of some wood-destroying fungi. Unpublished thesis. Penna. State College.
- Snell, W. H., Hutchinson, W. G. and Newton, K. H. 1928. Temperature and moisture relations of *Fomes roseus* and *Trametes subroseus*. Mycologia 20: 276-291.
- Verrall, A. F. 1934. Cultural studies of Fomes igniarius. Unpublished thesis. University of Minn.
- White, J. H. 1910. On the biology of Fomes applanatus. Trans. Roy. Can. Inst. 11:133-174.

INDEX TO AMERICAN BOTANICAL LITERATURE 1935-1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

- Nichols, G. E. Polytrichum and Pogonatum species of the eastern United States. Bryologist 60: 1-10. Ja-F 1937.
- Nielsen, E. L. & Humphrey, L. M. Grass studies. I. Chromosome numbers in certain members of the tribes Festuceae, Hordeae, Aveneae, Agrostideae, Chlorideae, Phalarideae and Tripsaceae. Am. Jour. Bot. 24: 276–279. f. 1–23. My 1937
- Norris, E. R., Simeon, M. K. & Williams, H. B. The vitamin B and vitamin C content of marine algae. Jour. of Nutrition 13: 425-433. Ap 1937.
- O'Leary, K. & Guterman, C. E. F. Penicillium rot of lily bulbs and its control by calcium hypochlorite. Contr. Boyce Thompson Inst. 8: 361-374. f. I. Ja-Mr 1937.
- Osterhout, W. J. V. Changes of apparent ionic mobilities in protoplasm I. Jour. Gen. Physiol. 20: 13-43. f. 1-12. 20 S 1936. II. The action of guaiacol as affected by pH. Jour. Gen. Physiol. 20: 685-693. f. 1-3. 20 My 1937.
- Overbeck, J. van. Effect of the roots on the production of auxin by the coleoptile. Proc. Nat. Acad. Sci. 23: 272-276. f. 1. My 1937.
- Palmer, E. J. Benjamin Franklin Bush. Am. Midl. Nat. 18: i-vi. illust. My 1937.
- Parodi, L. R. Algunas Gramíneas exóticas naturalizadas en la Argentina. Rev. Argentina Agron. 4:43-50. Mr 1937.
- Parodi, L. R. Algunas Gramíneas nuevas para la flora Uruguaya. Revista Sudamer. Bot. 4: 177-178. Mr 1937.
- Parreiras Horta, P. Orchidologia e Barbosa Rodrigues. Rodriguesia 2: 181–186. Je-S 1936.
- Pax, F. Euphorbiaceae americanae novae II. Repert. Spec. Nov. 41: 224-226. 25 F 1937.
- Peck, M. E. New plants from Oregon. Proc. Biol. Soc. Washington 50:93-94. 22 Je 1937.
- Peebles, R. H. Opuntia Wrightiana (Baxter) comb. nov. Desert 9: 43-44. illust. Ap 1937.

Peto, F. H. Genetical studies on mutants in the progeny of heat-treated barley. Canadian Jour. Res. 15: 217-229. pl. 1. My 1937.

Phillis, E. & Mason, T. G. On the effects of light and of oxygen on the uptake of sugar by the foliage leaf. Ann. Bot. II.

1:231-237. pl. 9. Ap 1937.

Pilger, R. Species nonnullae brasilienses novae. Repert. Spec. Nov. 41: 222-224. 25 F 1937.

Pilger, R. Zwei neue *Diplusodon*- Arten aus Brasilien. Repert. Spec. Nov. 41: 221. 25 F 1937.

Pittier, H. Los Musgos de Venezuela. Bol. Soc. Venezolana Cien. Nat. 27: [1-38]. Au-O 1936.

Pope, M. N. The time factor in pollen-tube growth and fertilization in barley. Jour. Agr. Res. 54: 525-529. pl. 1, 2+f. 1. 1 Ap 1937.

Porter, D. R. Inheritance of certain fruit and seed characters in watermelons. Hilgardia 10: 489-509. f. 1-8. Ja 1937.

Sears, E. R. Cytological phenomena connected with self-sterility in the flowering plants. Genetics 22: 130-181. pl. 1, 2+ f. 1-4. Ja 1937.

Seaver, B. Additional data on sex reactions in monospore races of Neurospora tetrasperma. Mycologia 29: 258-265. f. 1-7.

Mr-Ap 1937.

Seaver, F. J. Photographs and descriptions of cup-fungi. XXV. Urnula geaster. Mycologia 29: 60-65. f. 1-3. Ja-F 1937; XXVI. The genus Diplocarpa. Mycologia 29: 174-177. f. 1. Mr-Ap 1937.

Servazzi, O. Sulla biologia di *Pestalotia macrotrichia* Kleb. Bol. Lab. Osservat. Fitopat. Torino 13: 72-92. pl. 1, 2.

O-D 1936.

Severson, G. Alcohol yields from acid saccharified cereals. Iowa State Coll. Jour. Sci. 11: 215-220. Ja 1937.

Shoop, C. Irregularities in the floral parts of Tradescantia ozarkana. Rhodora 39: 46-49. F 1937.

Shull, G. H. New experiences with Oenothera mut. pollicata. Am. Nat. 71: 69-82. f. 1. Ja-F 1937.

Siderov, F. F. Züchtung Phytophtorawiderstandsfahiger Kartoffelsarten. Phytopathology 27: 211-241. f. 1. Mr 1937.

Silberschmidt, K. A importancia da "especie" no systema das plantas e a tentativa da sua delimitação por novos methodos. Arch. Inst. Biol. São Paulo 7: 33-50. pl. 6, 7+f. 1-3. 1936.

Silberschmidt, K. & Kramer, M. Sobre substancias vegetaes que estimulam o alongamento e a divisão das cellulas. Arch. Inst. Biol. São Paulo 7: 125. pl. 21-23+f. 1-3. 1936.

- Singer, R. Bemerkungen über einige Basidiomyceten. Ann. Myc. 34: 423-434. 31 D 1936.
- Singh, B. N., Das, K. & Chalam, G. V. Changing density of weed flora on arable land during the course of the "rabi" season. Jour. Am. Soc. Agron. 29: 204-212. f. 1-5. Mr 1937.
- Singh, B. N., Singh, S. N. & Srivastava, M. B. Photoperiodism, a factor in determining the manurial efficiency and distribution of *Crotalaria juncea*. Jour. Am. Soc. Agron. 29: 123-133. f. 1-5. Ja 1937.
- Sinnott, E. W. Morphology as a dynamic science. Science II. 85: 61-65. 15 Ja 1937.
- Sinnott, E. W. The genetic control of developmental relationships. Am. Nat. 71:113-119. Mr-Ap 1937.
- Skottsberg, C. Greigia Berteroi Skottsb. and its systematic position. Acta Horti Götoburg. 11: 209-222. f. 1-33. 1936.
- **Skovsted, A.** Cytological studies in cotton. IV Chromosome conjugation in interspecific hybrids. Jour. Genetics **34**: 96-134. pl. 1-3+f. 1-27. F 1937.
- Sleumer, H. Neue Ouratea-Arten aus Südamerika. Notizbl. Bot. Gart. Berlin 13: 349-356. 30 D 1936.
- Sleumer, H. Über die Gattung Metteniusa Karsten (= Aveledoa Pittier). Notizbl. Bot. Gart. Berlin 13: 359-361. 30 D 1936.
- Sleumer, H. Über die neue Flacourtiaceengattung Spruceanthus. Notizbl. Bot. Gart. Berlin 13: 362-363. 30 D 1936.
- Small, J. K. Allium stellatum. Addisonia 20: 6-7. pl. 644. 30 Mr 1937.
- Small, J. K. Eustylis purpurea. Addisonia 20: 13-14. pl. 647. 30 Mr 1937.
- Small, J. K. Herbertia Drummondii. Addisonia 20: 3-4. pl. 642. 30 Mr. 1937.
- Smart, R. F. Influence of certain external factors on spore germination in the myxomycetes. Am. Jour. Bot. 24: 145-159. f. 1-3. Mr 1937.
- Smith, A. What grows where. Jour. Cactus & Succ. Soc. Am. 8: 105-107. Ja 1937.
- Smith, A. H. New and unusual agarics from the western United States. Mycologia 29: 45-59. f. 1-3. Ja-F 1937.
- Smith, B. W. Notes on the cytology and distribution of the Dioscoreaceae. Bull. Torrey Club 64: 189-197. f. 1, 2. Ap 1937.
- Smith, L. B. Cryptanthus Glaziovii. Addisonia 20: 9-10. pl. 645. 30 Mr. 1937.

Smith, O. Influence of storage temperature and humidity on seed value of potatoes. Cornell Univ. Agr. Exp. Sta. Bull. 663: 1-31. f. 1-13. Ja 1937.

Spangler, R. C. Positions of megasporophylls and microsporophylls of *Selaginella*. Jour. So. Appalachian Bot. Club 2: 6-10. Ja 1937.

Spencer, E. L. Frenching of tobacco and thallium toxicity. Am. Jour. Bot. 24: 16-24. f. 1, 2. 26 Ja 1937.

Spoehr, H. A., Smith, J. H. C. & others. Biochemical investigations. Carnegie Inst. Washington Year Book 35: 198-208. 11 D 1936.

Sprague, G. F. Hybrid vigor and growth rates in a maize cross and its reciprocal. Jour. Agr. Res. 53: 819-830. f. 1-3. 1 D 1936.

Sprague, R. Relative susceptibility of certain species of Gramineae to Cercosporella herpotrichoides. Jour. Agr. Res. 53: 659-670. 1 N 1936.

Sprague, R. Undescribed species of *Cercosporella* and *Cercospora* on certain grasses in Oregon and Washington. Mycologia 29: 199–206. f. 1-3. Mr-Ap 1937.

Stacey, J. W. Notes on Carex VIII. Leafl. West. Bot. 2: 13-16. 27 Ja 1937.

Stahel, G. Banana leaf spot (Cercospora musae). Trop. Agr. 14: 59-60. Mr 1937.

Stahel, G. The banana leaf speckle in Surinam caused by *Chloridium musae* nov. spec. and another related banana disease. Trop. Agr. 14: 42-45. f. 1-17. F 1937.

Stakman, E. C. The promise of modern botany for man's welfare through plant protection. Sci. Monthly 44: 117-130. F 1937.

Stanfield, J. F. Hydrogen ion concentration and sexual expression in *Lychnis dioica* L. Plant Physiol. 12: 151-162. f. 1, 2. Ja 1937.

Stanley, W. M. Crystalline tobacco mosaic virus protein. Am. Jour. Bot. 24: 59-68. f. 1, 2. F 1937.

Stanley, W. M. The isolation of tobacco ring spot and other virus proteins by ultracentrifugation. Science II. 85: 181-183. 12 F 1937.

Stebbins, G. L. Critical notes on Lactuca and related genera. Jour. Bot. 75: 12-18. Ja 1937.

Steenis, C. G. G. J. van. Cycles of drought and reafforestation in the U.S.A. seen in the light of a new botanical hypothesis on the origin of deserts in general. Bull. Jard. Bot. Buitenzorg III. 14: 50-55. D 1936.

- Steere, W. C. Critical bryophytes from the Keweenaw Peninsula, Michigan. Rhodora 39: 1-14. f. 1-6. 11 Ja 1937; 33-46. F 1937.
 - Stehlé, H. Aperçu sur la végétation de la Guadeleupe. Rev. Bot. Appl. Agr. Trop. 16: 969-973. D 1936.
- Steidtmann, W. E. A preliminary report on the anatomy and affinities of *Medullosa Noéi* sp. nov. from the Pennsylvanian of Illinois. Am. Jour. Bot. 24: 124-125. f. A, 1-4. Mr 1937.
 - Stevens, N. E. Was there an outbreak of bacterial wilt of corn in central Illinois in 1891 and 1892? Trans. Illinois Acad. Sci. 29: 73-75. D 1936.
 - Stevens, O. A. The evening star. Am. Bot. 43: 11-15. Ja 1937.
 - Stevenson, J. A. & Cash, E. K. The new fungus names proposed by C. G. Lloyd. Lloyd Lib. Bull. 35: 1–209. 1936.
 - Stout, A. B. Two new daylilies. Jour. N. Y. Bot. Gard. 38: 60-61. illust. Mr 1937.
 - Stout, A. B. Vegetative propagation of daylilies. Jour. N. Y. Bot. Gard. 38: 13-17. f. 1, 2. Ja 1937.
 - Strong, F. C. Shade tree diseases of Michigan. Proc. Nat. Shade Tree Conf. 12: 103-113. S 1936.
 - Stubbs, M. W. Certain viroses of the garden pea, Pisum sativum. Phytopathology 27: 242-266. f. 1-3. Mr 1937.
 - Suliotis, M. Contributi alla patalogia dei Pioppi IV. Un disseccamento di piantine di Pioppo canadense e P. caroliniano. Bol. Lab. Osservat. Fitopat. Torino 13: 62-72. f. 1-14. O-D 1936.
 - Summerhayes, V. S. Epidendrum coriifolium. Curt. Bot. Mag. 160: pl. 9477. 12 F 1937.

From Guatemala to Peru.

- Sumstine, D. R. New species of Hyphomycetes. Mycologia 29: 250-251. Mr-Ap 1937.
- Sunneson, C. A. Emasculation of wheat by chilling. Jour. Am. Soc. Agron. 29: 247-249. Mr 1937.
- Swabey, C. Method of killing standing trees. Trop. Agr. 14: 50-51. F 1937.
- Swoboda, F. Über den Fruchtkörperbau und die systematische Stellung von Lanopila Fries. Ann. Myc. 35: 1-14. 1937.
- Taft, C. E. The life history of a new species of Mesotaenium.

 Bull. Torrey Club 64: 75-79. f. 1-13. F 1937.
- Takahashi, W. N. & Rawlins, T. E. Stream double refraction of preparations of crystalline tobacco-mosaic protein. Science II. 85: 103-104. 22 Ja 1937.

- Tapke, V. F. A method of inoculating seed barley with black loose smut for use in studies on physiologic races. Phytopathology 27: 115-116. Ja 1937.
- Taubenhaus, J. J. & Christenson, L. D. Rôle of insects in the distribution of cotton wilt caused by Fusarium vasinfectum. Jour. Agr. Res. 53: 703-712. f. 1. 1 N 1936.
- Taubenhaus, J. J. & Ezekiel, W. N. A rating of plants with reference to their relative resistance or susceptibility to *Phymatotrichum* root rot. Texas Agr. Exp. Sta. Bull. 527: 5-52. S 1936.
- Tehon, L. R. & Jacobs, H. L. Verticillium root disease of American elms. Proc. Nat. Shade Tree Conf. 12: 128-140. illust. S 1936.
- **Tervet, I. W.** An experimental study of some fungi injurious to seedling flax. Phytopathology 27: 531-546. f. 1-3. Ap 1937.
- Theriot, I. Mousses de l'Equateur. Rev. Bryol. 9: 5-36. f. 1-18. 25 N 1936.
- Thomas, E. E. Reclamation of white-alkali soils in the Imperial Valley. Univ. California Agr. Exp. Sta. Bull. 601: 1-15. f. 1-4. Il 1936.
- Thornberry, H. H. Comparative studies on cultures of *Phytomonas lactucae-scariolae* n. sp. and *Phytomonas pruni*. Phytopathology 27: 109-110. Ja 1937.
- Thornton, N. C. Carbon dioxide storage. IX. Germination of lettuce seeds at high temperatures in both light and darkness. Contr. Boyce Thompson Inst. 8: 25-40. Ja-Mr 1936; X. 137-148. f. 1. O-D 1937.
- Tidd, J. S. Studies concerning the reaction of barley to two undescribed physiologic races of barley mildew, *Erysiphe graminis hordei* Marchal. Phytopathology 27: 51-68. f. 1, 2. Ja 1937.
- Tidestrom, I. Notes on Astragalus (Tournef.) L. Proc. Biol. Soc. Washington 50: 17-22. 23 F 1937.
- **Torrey, R. H.** Lichens on the Pilgrim Fathers. Torreya 37:16. Ja-F 1937.
- Tompkins, C. M., Tucker, C. M. & Gardner, M. W. Phytop-thora root rot of cauliflower. Jour. Agr. Res. 53: 685-692 pl. 1+f. 1, 2. 1 N 1936.
- Trouvelot, B. Le Doryphore de la pomme de terre (Leptinotarsa decembineata Say) en Amérique du Nord. Ann. Epiphyties et Phytogen. II. 1: 277-336. f. 1-10. 1936.
- Tukey, H. B. & Lee, F. A. Embryo abortion in the peach in relation to chemical composition and season of fruit ripening. Bot. Gaz. 98: 586-597. f. 1, 2. Mr 1937.

- Wherry, E. T. Clematis Addisonii Britton. Claytonia 3: 42-43. Ja 1937.
- Wherry, E. T. Miscellaneous eastern Polemoniaceae. Bartonia 18: 52-59. pl. 6+f. 1, 2. 17 D 1936.
- Wherry, E. T. Southern occurrences of *Dryopteris Clintoniana*. Am. Fern. Jour. 27: 1-5. pl. 1. Ja-Mr 1937.
- Wherry, E. T. Two plant-geographic notes. Jour. So. Appalachian Bot. Club 2: 1-2. Ja 1937.
- Whetzel, H. H. Septotinia, a new genus of the Ciborioideae. Mycologia 29: 128-146. f. 1-18. Ja-F 1937.
- Whipple, O. C. Spotted wilt of garden pea. Phytopathology 26: 918-920. f. 1. S 1936.
- Whitaker, T. W. Fragmentation in *Tradescantia*. Am. Jour. Bot. 26: 517-519. f. 1-3. O 1936.
- White, A. & Sloane, B. L. The Stapelieae. 1: i-xvi. 1-407. pl. 1-7+f. 1-349; 2: 409-818. pl. 8-22+f. 350-828; 3: 819-1185. pl. 23-39+f. 829-1233. Pasadena. Abbey San Encino Press. 1937.
- White, P. R. Plant tissue cultures. Bot. Rev. 2: 419-437. Au 1936.
 - White, P. R. Seasonal fluctuations in growth rates of excised tomato root tips. Plant Physiol. 12: 183-190. f. 1-4. Ja 1937
 - White, R. P. Rhododendron wilt and root rot. New Jersey Agr. Exp. Sta. Bull. 615: 3-32. f. 1-18. F 1937.
 - White, W. L. A new species of Chondropodium on Pseudotsuga taxifolia. Mycologia 28: 433-438. f. 1-7. 1 O 1936.
 - Whitney, L. D. & Hosaka, E. Y. New species of Hawaiian *Panicum* and *Eragrostis*. Bernice P. Bishop Mus. Occ. Papers 12⁵: 1-6. f. 1, 2. 8 Jl 1936.
 - Wieland, G. R. Cycadeoid investigations and field work. Carnegie Inst. Washington Year Book 35: 333-340. 11 D 1936.
 - Wieland, G. R. Fossil Cycad National Monument. Science II. 85: 287-289. 19 Mr 1937.
 - Wiggins, I. L. A resurrection and revision of the genus *Iliamna* Greene. Contr. Dudley Herb. Stanford Univ. 1: 213–229. pl. 20. 16 Je 1936.
 - Wiggins, I. L. Notes on the habitat and distribution of Crusonia wrightiana. Jour. Cactus & Succ. Soc. Am. 8: 134-135. illust. F 1937.
 - Williams, L. O. A monograph of the genus *Mertensia* in North America. Ann. Missouri Bot. Gard. 24: 17-159. f. 1-16. F 1937.

The genus Cooperia

H. HAROLD HUME

Bulbs collected by the Scotch plant explorer, Thomas Drummond, in eastern Texas were sent to the Botanic Garden, Glasgow, in 1834, and from there distributed to a number of plant lovers in Scotland and England early in 1835. Among the first flowers produced from these bulbs in Great Britain was one secured by Joseph Cooper, gardener at Wentworth House in Yorkshire, England, the country seat of Earl Fitzwilliam. This estate evidently had plant collections of considerable size as it has been referred to as a botanic garden. With the Wentworth specimen in hand, William Herbert (1836) established the genus Cooperia commemorating the name of Mr. Cooper. To the type species the name C. Drummondii was given in honor of Thomas Drummond. The illustration (Botanical Register pl. 1835) accompanying the description bears the date February 1, 1836.

Among Drummond's bulbs was another belonging to the same group which flowered in the collection of Doctor Neill, Canonmills, near Edinburgh, Scotland, July, 1835. This presented certain characters different from C. Drummondii, and D. Don (1836) described it as Zephyranthes Drummondii without having seen the living plant. The plate (Sweet, Brit. Fl. Gard. pl. 328. 1836) from a drawing by James MacNab, accompanying the description, is dated March 1, 1836. A short time after Herbert had established the genus Cooperia, R. Graham (1836) published a description of Don's Z. Drummondii, under the name Sceptranthes Drummondii, from a flower produced by J. Dickson and Son early in March, 1836. He believed it to be distinct from both Zephyranthes and Cooperia and pointed out certain respects in which he thought it differed. Later Herbert properly described this plant under Cooperia giving it the name Cooperia pedunculata, the specific name, Drummondii, given by Don and by Graham, having been applied already, as just stated, to another species in the genus.

It is worth noting that three generic names were used, all within a very short period of time: Cooperia (February 1, 1836), Zephyranthes (March 1, 1836), and Sceptranthes (March 10, 1836), evidence of the keen botanical interest in these plants at the time of their first flowering in Great Britain. Priority in establishing the genus belongs to William Herbert.

While Cooperia is related to Zephyranthes so closely that the two frequently have been confused and hybrids between them have been secured, it is to be separated from the latter genus by the longer perianth-tube, [The Bulletin for January (65: 1-78) was issued January 6, 1938]

very short filaments, erect, not versatile anthers, scented flowers, and night-blooming habit.

COOPERIA Herb. Bot. Reg. pl. 1835. F 1836.

Sceptranthes Graham, Edinb. New Phil. Jour. 20: 413, 414. Mr. 1836.

Acaulescent herbs with coated bulbs and linear, glabrous, erect, recumbent, or decumbent leaves; flowers borne singly on an erect hollow scape; spathe membranous, tubular in the lower part; perianth white tinged outside with red or green of six parts (three sepals and three petals) partly united below to form a tube, the tube elongate, cylindric or slightly dilated upward; calyx- and corolla-lobes usually spreading; stamens six, with very short triangular filaments, adnate up to the throat of the perianth tube; anthers slender, erect (not versatile); stigmas round-lobed; style filiform; ovary threecelled, sessile or stipitate; capsule membranous, loculicidal, three-lobed; seeds numerous, flattened, thin, black. Flowers produced in spring, primrose scented, opening in the evening.

Though John Lindley published at one and the same time descriptions by Herbert (1836) of two plants in connection with Herbert's definition of the genus, Cooperia Drummondii should be regarded as the type. It is given first place in the discussion with a brief note on C. chlorosolen added. Later Herbert (1837) placed the latter as a variety of C. Drummondii.

In North America, cooperias of one kind or another are native from northeastern Mexico to New Mexico, Kansas and southwestern Louisiana. Outside this area only one other species, C. albicans, from Peru, is known.

KEY TO COOPERIA

Ovary not stipitate.

out.

Perianth-tube greatly elongate [6.5-18 cm.]: style as long as or longer than the perianth tube. Calyx- and corolla-lobes relatively broad, imbricate below the middle.

Perianth-limb rather small, less than 4 cm. wide; tube slender, red-tinged; calyx-lobes 1. C. Drummondii white. Perianth-limb large, over 4 cm. wide; tube stout, green; calyx-lobes lined with green with-1a. C. Drummondii chlorosolen

Calyx- and corolla-lobes narrow, not imbricate.

2. C. Traubii

Perianth-tube shorter [7-11.2 cm. see descr.]; style much shorter than the perianth-tube: calyx- and corolla-lobes broadly lanceolate, 4-4.5 cm. long. (Peruvian) 3. C. albicans

Ovary stipitate Perianth-tube relatively short [0.5-9 cm.] calyx- and corolla-lobes imbricate: ovary and stipe 4. C. pedunculata included in the spathe.

1. COOPERIA DRUMMONDII Herb.

Bot. Reg. 22: pl. 1835. F 1836.

Cooperia Drummondiana Herb. Amaryll. 178. 1837.

Bulb large, subglobose, 2×3 cm., the neck 2 to 9 cm. long, not pronounced in some specimens, the tunics black; leaves 2 to 5, narrow, linear, gray-green, upright or declinate, 2 mm. wide, 30 cm. long; scapes 2 to 3 mm. wide, 10 to 21 cm. long, commonly solitary or two together, gray-green above, shading to reddish-brown below; spathe slender, thin, membranous, pink-tinted, commonly looped at the tip, sometimes bifid, 3.5 to 6 cm. long, 2.3 to 4.2 cm. to the slit; the spathe-tube embracing and extending above the ovary, about one third as long as the perianth-tube; stipe none; perianth-tube slender, elongate, greenish white or pinkish white, 6.5 to 18 cm. long, 2.5 mm. thick; perianth-limb opening flat, or stellate with margins of lobes incurved, white, pink tinted on outer surface, calyx lobes ovate to lanceolate 2.4 cm. long, 1.3 cm. wide, with blunt tips, corolla-lobes 2.2 cm. long, 1.2 cm. wide; stamens erect, filaments white 3 mm. long, 1.5 mm. wide, rectangular in outline, apices concave; anthers erect creamy yellow, 9 mm. long, attached to filaments one third of length from base; ovary almost cylindric, 6 mm. long; style white slightly clavate, 9.5 cm. long reaching to middle of anthers or extending above them; stigmas lobed, the lobes depressed 1 mm. × 1.5 to 2 mm.; capsule of three rounded depressed lobes, 1 cm. × 1.5 to 2 cm.; seeds numerous thin, flattened, black, half circular or rounded triangular in outline, 5 mm. X 8mm.—Season May-August.

Although there are specimens of *C. Drummondii* collected by Drummond (411) in various herbaria (Kew, British Museum, Edinburgh), a type specimen is unknown. Herbert based his diagnosis upon a fresh flower produced by a bulb collected by Drummond. All of Drummond's herbarium specimens seen are without bulbs. Apparently he removed them before sending his material from Texas. Lindheimer collected the species at an early date, 1847–1849. Herbert had also received bulbs of Drummond's collection which he planted and flowered in his greenhouse at Spofforth, England.

Of all the cooperias known at this time, *C. Drummondii* is the most widely distributed. It is a native plant in northern Mexico and ranges as far north as New Mexico, Kansas, and Louisiana, with its most abundant distribution in Texas.

1a. Cooperia Drummondii var. chlorosolen Herb.

Baker Handb. Amaryll. 27. 1888.

Cooperia chlorosolen Herb. Bot. Reg. under pl. 1835. F 1836. Cooperia Drummondiana var. chlorosolen Herb. Amaryll. 178. pl. 24, f. 1. 1837.

"Perianth tube stouter, tinged with green; limb longer, less rotate. Leaves a little broader." J. G. Baker (1888).

Herbert secured flowers of *C. Drummondii* in his greenhouse at Spofforth, England, from bulbs collected by Drummond in Texas between the Brazos River and San Felipe (Drummond 411). Another bulb of the same

lot bore leaves and early in January, 1836, produced a flower that differed in some particulars from those of *C. Drummondii*. This plant he described briefly as *C. chlorosolen* (1836) and two months later followed with a colored plate and a longer, more detailed description. At this time he said it "differs from *Cooperia Drummondii*... in having a much larger limb, the tube green, and the sepals lined with green on the outside, the leaves longer and wider, the filaments free from the tube one-eighth instead of one-sixteenth and the style shorter than the tube."

Later Herbert (1837) placed his *Cooperia chlorosolen* as a variety of *C. Drummondii* and changed the spelling of the latter specific name without offering any explanation as to why he reduced it to a variety. Baker accepted Herbert's disposition of the plant and supplied the brief de-

scription quoted above.

Cooperia Drummondii chlorosolen rests solely upon Herbert's original description. Specimens labeled "chlorosolen" are in herbaria but they present in their dried state no characters by which they can be distinguished from the species. Features emphasized by Herbert and by Baker, and in a note by Weathers (1911) at a more recent date, "The variety has stouter flower-stems, flowers tinged with green and having less spreading segments" are not sufficient to establish the varietal position of the plant. All descriptions and comments, it appears probable, are based upon the original description by Herbert and no greater variations than are to be found among related plants are indicated. There is need for further field work and a careful study of growing flowering plants and their offspring if they can be secured before it can be determined whether it is actually entitled to varietal rank or whether it may be a species or whether it is only a color variant. Nowhere does Herbert indicate that he had secured more than a single flower of it. The illustrations (Sceptranthes Drummondii and Cooperia chlorosolen) given by Loudon (1841) show two flowers that are quite distinct in general appearance and S. Drummondii is quite different from Herbert's (1836) illustration of C. Drummondii.

2. Cooperia Traubii Hayward

Am. Amaryll. Soc. 3: 63-66. 1936.

Bulb globose 1.6 cm. diameter; the neck 2.7 cm. long; leaves about four, linear, glaucous, recumbent, to 22.5 cm. long; scape slender, cylindric, 17.5 to 19 cm. long; spathe cylindric, light tan-colored, about one-third as long as the perianth-tube, 4.8 cm. long over all, the tips 1.4 cm. long, slender, acute; stipe none; perianth-tube very slender, cylindric, expanded slightly at apex; perianth-limb star-like, white, faintly tinted pink outside, 5.5 cm. expanded, 15 cm. long including ovary, calyx- and corolla-lobes separated, slightly re-

curved at anthesis, white within, faintly pink tinted on outer surfaces of three sepals lanceolate, rounded at the tips, 3.4 cm. long, 6.9 mm. wide; stamens with very short white filaments; anthers erect, slender, light-colored; ovary 7 mm. × 5 mm.; style slender, white, 12.5 cm. long; stigmas white, with short rounded lobes expanded 3 mm. elevated about 10 mm. above anthers.—Season June.

This cooperia is known only from the vicinity of Angelton, Texas, where it grows in grassy plains. Bulbs were collected by R. H. Stansel and sent to Dr. H. P. Traub, Orlando, Florida. Flowers were produced in the trial garden of the American Amaryllis Society, Winter Park, Florida. One of these is preserved as the type specimen (1,634,673) in the U. S. National Herbarium. The species is most closely related to *Cooperia Drummondii* Herb., which it resembles in its non-stipitate ovary and length of the perianth-tube, but from which it apparently differs in narrow, slender leaves, larger flowers and separated, somewhat recurved calyxand corolla-lobes.

3. Cooperia albicans (Herb.) Sprague

Kew Bull. 386. 1928.

Lilio-Narcissus monanthus flore albicante tubo praelongo Feuillée, Jour. Obs. (Hist.) 29. pl. 20. (sinistra) 1725.

Pyrolirion albicans Herb. Amaryll. 184. 1837.

Zephyranthes albicans Baker Amaryll. 38. 1888.

Bulb medium size, subglobose, short-necked in specimens examined, black or dark-brown to brown, 2.5 cm. × 2 cm., without offsets; leaves 3 on specimen, slender below, widening upward thence tapering to apex, linear-oblanceolate, with incurved margins, striations present, 7-nerved, 2.5 to 4.0 mm. wide, 12 to 20 cm. long; scape 1 in specimen, subcylindric, 3.5 to 4.5 mm. wide, 7 cm. long; spathe membranous, 4.2 cm. long, 2.2 cm. to slit, shorter than the perianth-tube, unilateral with slender, acuminate tips; stipe none; perianth-tube slender, 7 cm. long, slightly expanded at summit, 11.2 cm. long, including ovary, greenish-white; perianth-limb white, about 7.5 cm. expansion; calyx-lobes broadly lanceolate, 4 to 4.5 cm. long, 1.7 cm. wide, separated near apex, imbricate near base, white, rounded; corolla-lobes 1.5 cm. wide, some slightly narrower; stamens with flattened deltoid filaments, slightly united toward base, upper parts oblong, tapered to apex, 1 m.×0.7 m.; anthers 3 mm. long; ovary oblong, 1 cm.×5 mm., style short, about 3 mm.; stigmas spatulate, slightly above the anthers, 3-4 mm. expansion.

Cooperia albicans, known in botanical literature under one name or another over a period of more than two centuries, has an interesting history. It was discovered in dry soil at Ylo, Peru. Feuillée (1725) described it under the phrase "Lilio-Narcissus, flore albicante tubo praelongo."

Herbert based his disposition of the plant upon Feuillée's discussion and referred it to Pyrolirion as a doubtful species with the name P. albicans, at the same time indicating his thought that it might be a Cooperia. Roemer (1847) followed Herbert, supplied a brief description and, with a question mark, expressed doubt concerning its classification. Kunth (1850) placed it under Pyrolirion as a doubtful species with a brief description based upon Herbert's diagnosis. Baker (1888) transferred it to his Pyrolirion section of Zephyranthes as Z. albicans. There it remained until Sprague (1928) secured fresh flowers from bulbs collected at Mollendo, Peru, furnished by Major Albert Pam. His conclusion that the fresh material belonged with Feuillée's plant and both to the genus Cooperia admits of no doubt. Hence the combination Cooperia albicans (Herb.) Sprague.

Specimens of this plant in herbaria are not numerous. In addition to those in the herbarium of the Royal Botanic Garden, Kew, there is a fine set in the Museum Botanicum Berolinense. This consists of nineteen more or less complete specimens on four sheets, collected in 1902, by Dr. A. Weberbauer (Flora von Peru 1510), at Mollendo, Peru. There is in the Herbarium Field Museum a specimen, 609,717, of this collection by Weberbauer. It will be noted that in the same locality the bulbs presented by Major Albert Pam to the Royal Botanic Gardens, Kew, from which Sprague secured his flower specimens were collected. The presence of this species far south of the North American area for the genus and on the other side of the equator is of interest to the student of plant geography. Its distribution is paralleled in the related genera Zephyranthes and Habranthus, species belonging to which are similarly separated.

Cooperia albicans is apparently the largest flowered species of the cooperias known at this time. It is quite distinct from others in its wide, reflexed calyx- and corolla-lobes. In its native home it is known as "amancaes" or "flor de amancaes."

4. COOPERIA PEDUNCULATA Herb.

Amaryll. 179. pl. 42, f. 3. 1837.

Zephyranthes Drummondii D. Don Sweet Brit. Fl. Gard. pl. 328. Mr 1 1836.

Sceptranthes Drummondii Graham Edinb. New Phil. Jour. 20: 413. Mr 10 1836.

Bulb large, torpedo-shaped when young, flattened-globose when old, dark-brown to black, 2.5 cm.×4 cm.; the neck long, 5–8 cm., both bulb and neck with abundant covering of old sloughing tunics; leaves 4 to 6, linear, 5 to 6 mm. wide, glaucous-green, twisted and recumbent; scapes solitary or 2 or more

together, cylindric, 3 mm. wide, 13 to 16 cm. long, glaucous-green; spathe thin and membranous, sack-like, pink, 3.5 to 4.5 cm. long, 2.2 to 3.7 cm. to slit, the tubular portion extending well above the ovary and completely enclosing it, the tips bifid or looped, attenuated; stipe short, 0.5 to 3.3 cm. long; perianth-tube cylindric, slender, expanded very slightly and gradually upward, 3 to 4 cm. long, with ovary 6.5 to 9 cm. long; perianth-limb broadly funnel-form,? expansion 5 cm., white, flushed pink without; calyx-lobes oblong-obovate, 2.7 cm.×1.6 cm., imbricate, white flushed pink outwardly, apex rounded-cuspidate; corolla-lobes white tinted pink, rounded at the apex; stamens in two sets of placements, one slightly above the other; filaments short, white, triangular, 1 to 2.5 mm. long, anthers cream-yellow, erect, 6-8 mm. long; stigmas white, rounded, 2 mm. expansion; ovary ovoid, 1 cm.×5 mm.; capsule bluntly triangular, 1.6 cm. along each side, 1.5 cm. high, slightly tapering downward; seeds numerous, thin, black, 4×7 mm. to 6×9 mm.

Compared with Cooperia Drummondii the distribution of C. pedunculata is restricted. It is found in Texas and in the adjacent parts of Mexico—Coahuila, Nuevo Leon, and Tamaulipas.

Its bulbs are torpedo-shaped when young and amply provided with contractile roots¹ by means of which they are pulled down into the soil. Under garden conditions in Florida's sandy soil, bulbs have been found at a depth of 30 cm., but, judging from the necks of herbarium specimens, they are commonly found at a depth of 8 to 10 cm. under natural conditions. Mature native bulbs are turbinoid, long-necked, and provided with copious sloughing coats. Such coats commonly are associated also with certain species of bulbs, inhabiting dry soils, belonging to the related genus Zephyranthes.

SPECIES EXCLUDED

COOPERIA MEXICANA Herb. Amaryll. 182. 1837.

Cooperia mexicana Herb. was listed by Herbert as a doubtful species, the bulbs and leaves only of which were known to him. It was imported from Mexico by Mr. Loddiges, Hackney, England. Lacking a description of the flower, it is not possible to assign the name to any known plant. Cooperia mexicana Herb. must therefore be regarded as a nomen nudum. The name has been placed as a synonym (1893) for C. Drummondii, but upon what grounds is not apparent.

¹ Contractile roots probably are to be found on bulbs of all species of *Cooperia*. Those of *C. Drummondii* have been the subject of special study by Church (1919).

Cooperia miradorensis Kränz.

Repert. Sp. Nov. 21: 75. 1925.

Cooperia miradorensis Kränzlin was based upon a specimen (Liebmann 7925:), consisting of a scape and flower, now in the herbarium of the University of Copenhagen. It was collected by Frederik M. Liebmann in a field at Mirador, Mexico, where he made his headquarters from time to time while collecting plants and herbarium specimens in Mexico for the Botanical Garden of Copenhagen during the period February 7, 1841, to May 6, 1843. Owing to the scanty nature of the material and the difficulty of making out certain features, Kränzlin's description is lacking in important details. Opportunity has not been afforded for examining the original specimen, but through the kindness of Dr. S. C. Simms, late Director, Field Museum of Natural History, a photograph of it has been available. There is nothing in the original description or apparent in the photograph to indicate in what respects this plant is to be set apart from the genus Zephyranthes. To this genus it quite apparently belongs and it is so referred here without attempting to indicate definitely the identity of the species. It closely resembles Z. macrosiphon Baker, a Mexican species the exact native habitat of which is unknown.

GARDEN VALUES

Fine flowering clumps of Cooperia may be secured in the garden by planting a number of bulbs close together (two to three inches apart) and three to four inches deep. Mature, well grown bulbs usually produce several flowers in spring (April to June). Since they open in the evening and remain open during the night they are valuable in the garden for that time of day and the primrose scent of the flowers is an added attraction. They are easily grown in well drained soils in southern gardens. Bulbs are readily grown from seed and from bulb cuttings. Cooperias of one sort or another are to be found here and there in gardens of the Gulf Coast country. In Florida they have been noted at different points from Key West to Gainesville.

THE UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA

Baker, J. G. 1888. Zephyranthes albicans. In his: Handbook of the Amaryllideae. 38.

Church, M. B. 1919. The Development and structure of the bulb in Cooperia Drummondii. Bull. Torrey Club 46: 337-362. pl. 14-16.

Don, D. 1836. Zephyranthes Drummondii. In: Sweet, British Flower Garden II. 4: pl. 328. 1 Mr.

Graham, R. 1836. Sceptranthes. Edinb. New Phil. Jour. 20: 413, 414. 10 Mr.

Herbert, William. 1836. Cooperia Drummondii. Bot. Reg. pl. 1835.

. 1837. Cooperia. In his: Amaryllidaceae. 178–182.

Jackson, B. D. 1893. Index kewensis 1: 610.

Kunth, C. S. 1850. P. albicans. In his: Enumeratio Plantarum 5: 491.

Loudon, Jane. 1841. Cooperia. In her: Ladies' Flower Garden of Ornamental Bulbous Plants. 113, 114. pl. 26.

Roemer, M. J. 1847. *P[yrolirion] albicans*. In his: Familiarum naturalium . . . synopses monographiceae 4: 127.

Weathers, John. 1911. Cooperia. In his: The Bulb Book 151.



Additional Miocene plants from Grand Coulee, Washington

EDWARD W. BERRY (WITH EIGHT FIGURES)

In 1931 I published an account of a Miocene flora collected at Grand Coulee, Washington, by several interested citizens of that state.¹

Since that time I have received material from this same locality from George F. Beck of the State Normal School at Ellensburg, Washington. Mr. Beck is himself making a study of the fossil woods of the state and his results promise to be of the greatest importance not only in themselves but as a check on the identification of the fossil leaves from the associated beds.

Since it seems hardly likely that I will have the opportunity to make any extensive contribution to this fascinating problem, it seems highly desirable to place on record the additional species that have been recognized from Grand Coulee.

The flora thus far discovered at this locality is strikingly similar to that described from the Latah formation of eastern Washington and Idaho and any conclusions regarding its ecology or botanical character would necessarily be similar to those reached from a study of the latter.²

The present additions to this flora comprise the following:

Castanea orientalis Chaney
Castanopsis consimilis (Newberry) Brooks
Cornus Becki Berry
Diospyros Andersonae Knowlton
Fagus pacifica Chaney
Ginkgo adiantoides (Unger) Heer
Juglans oregoniana Lesquereux
Liquidambar californicum Lesquereux
Magnolia Inglefieldi Heer (?)
Magnolia spectabilis Knowlton
Quercus spokanensis Knowlton
Quercus ursina Knowlton
Rhus Merrilli Chaney

The following deserve special comment:

Ginkgo adiantoides (Unger) Heer (Figure 2)

Ginkgo adiantoides (Unger) Heer, Flora fossilis arctica, 5³: 21. pl. 2. f. 7-10. 1870.

¹ Berry, E. W. U. S. Geol. Survey Prof. Paper 170, pp. 31-42, pls. 11-13, 1931.

² Berry, E. W. Idem. 154, pp. 225-265, pls. 49-64, 1929.

Ward, U. S. Geol. Survey Sixth Ann. Rept., 549. pl. 31. f. 5, 6. 1886; idem., Bull. 7: 15. pl. 1. f. 5, 6. 1887.

Chaney, Chicago Univ. Walker Mus. Contr. 2: 159. pl. 5. f. 1. 1920.

Knowlton, U. S. Geol. Survey Prof. Paper 140: 25. pl. 8. f. 10, 11. 1926.

Berry, Geol. Survey Canada Bull. 42: 96, Natl. Museum Canada Bull. 63: 18, 1930.

Mason, Carnegie Publ. 346: 145. pl. 1. f. 1. 1927.

Ashlee, Northwest Science, 6: 72. 1932.

Although individually much less abundant than most of its associates the Ginkgo has an unparalleled geographic and geologic range. The leaves are very conservative in their organization and also in their great variability from the Jurassic to the present. Consequently authors differ in their specific segregations. It is customary to refer the leaves found in the Tertiary to Ginkgo adiantoides although they are indistinguishable from such Cretaceous forms as Ginkgo laramiensis Ward or Ginkgo pseudoadiantoides Hollick, or from selected specimens of the existing species.

It seems hardly possible that a single botanic species should continue unchanged through such a vast lapse of time, but if there are specific differences one would hardly expect the specific bounds to coincide with the artificial boundaries of the geologic time scale.

Although I have followed the traditional procedure in the present case, it would seem from the distinctly Asiatic relationship of so many of the associated species that these late Miocene examples from Washington, Oregon and Idaho are more likely to be identical with the living species than with the early Tertiary form which is so widely distributed throughout the Holarctic region. In fact Depape³ has not hesitated to refer lower Pliocene specimens from France to the existing *Gingko biloba* Linné.

The figured specimen from Grand Coulee is entire, a condition frequently seen in leaves of the existing species. I have numerous specimens of the latter that exactly match the fossil.

Juglans oregoniana Lesquereux

Juglans oregoniana Lesquereux, Mus. Comp. Zool. Mem. 6: 35. pl. 9. f. 10. 1878.

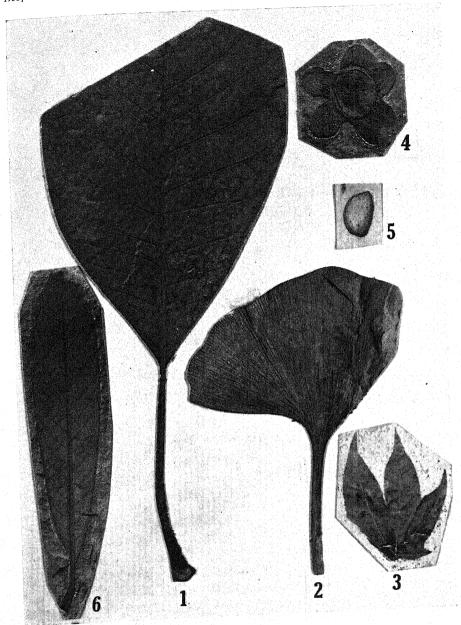
Knowlton, U. S. Geol. Survey Bull. 204: 36. 1902.

Rhus bendirei Lesquereux, U. S. Natl. Mus. Proc. 11: 15. 1888 (according to Knowlton).

Juglans hesperia Knowlton, U. S. Geol. Surv. 18th Ann. Rept., pt. 3: 723. pl. 99. f. 8. 1898.

Juglans egregia Berry, Idem. Prof. Paper 170: 35. pl. 11. f. 3. 1931 (not Lesquereux).

³ Depape, G. Compt. rendu Acad. Sci. 157: 957. 1913.



- Fig. 1. Magnolia spectabilis Knowlton.
 Fig. 2. Ginkgo adiantoides (Unger) Heer.
 Fig. 3. Liquidambar californicum Lesq.
 Fig. 4. Calyx of Diospyros Andersonae Knowlton.
 Fig. 5. Seed of Diospyros Andersonae Knowlton.
 Fig. 6. Castanopsis consimilis (Newberry) Brooks.

I am not sure that Juglans egregia as defined by Lesquereux represents a botanic species distinct from Juglans oregoniana Lesquereux since both are very similar and highly variable but I have only included the leaves from Grand Coulee which I identified as the former. As thus conceived the species includes material from the Mascall formation of Oregon and the Payette formation of Idaho.

Castanopsis consimilis (Newberry) Brooks

Figure 6

Quercus consimilis Newberry, Proc. U. S. Natl. Mus. 4: 505. 1883: U. S. Geol. Survey Mon. 35: 71. pl. 43. f. 2-5, 7-10. 1898.

Castanopsis consimilis Brooks, Ann. Carnegie Mus. 24: 285. pl. 6. f. 2; pl. 7. f. 3, 4; pl. 8. f. 1-5 etc., 1935.

Without implying complete agreement with Brooks' conclusions or the synonymy given by her for the above species, it would seem that a good case is made out for referring these leaves to *Castanopsis* instead of *Quercus*. I figure a typical specimen from Grand Coulee.

The genus, usually confused with other Fagaceae in the geological record, is represented by a single large tree (shrubby at high elevations) from southwestern Washington to southern California and by over a score of oriental species ranging from southern China to the eastern Himalayas and the Malay archipelago. The fossil is more like several of the Asiatic species than it is like the single surviving North American species.

Quercus ursina Knowlton

Figure 8

Quercus ursina Knowlton, U. S. Geol. Survey Bull. 204: p. 51. pl. 7. f. 2, 3. 1902. Berry, Idem. Prof. Paper 154: 246. 1929.

This species was based upon small 5 to 7 lobed leaves from the Mascall formation of the John Day basin in Oregon. It was subsequently detected in the Latah formation around Spokane, Washington and at both localities it was associated with the leaves identified as Quercus Merriami Knowlton. The leaf from the diatomaceous boulders at Grand Coulee which is here figured agrees very closely with Knowlton's types of Quercus ursina. It has 5 conical lobes prominently bristle-pointed and an extra bristle on one side near the tip. The base is less cuneate and more curved truncate, but is distinctly decurrent. Quercus ursina seems to have sufficient individuality to constitute a good botanical species. On the other hand its constant association with a great variety of highly variable oak leaves leads to a strong suspicion that it is simply a variant of one of these.

Magnolia spectabilis Knowlton

Figure 1

Magnolia spectabilis Knowlton, U. S. Geol. Survey Mon. 32:718. pl. 93. f. 1, 2. 1899.

Magnolia dayana Knowlton (not Cockerell) Idem., Prof. Paper 140: 41. pl. 24. f. 3. 1926.

Magnolia sp., Knowlton, Idem., pl. 27. f. 1.

The fine specimen from the brown sandy clay at Grand Coulee is identical with the material from the Latah formation at Spokane which Knowlton referred to *Magnolia dayana* Cockerell, a species from Chalk Bluff, California, and which I am sure is not that species.

The specimen from Spokane which Knowlton described as Magnolia sp. is, I believe, a variant of this same species. All of these appear to represent Magnolia spectabilis described originally from the supposed Miocene of Yellowstone Park. It would perhaps be useful to recharacterize this species which may be done in the following terms: Leaves prevailingly large, elliptical-lanceolate, with a cuneate base and an abruptly pointed, usually not extended tip. Margins entire, usually evenly rounded but sometimes slightly undulate. The texture is not thick and leathery as Knowlton stated or as is found in the modern American evergreen Magnolia foetida Sargent but, as near as I can make out was fairly thin and stiff and might merit the term subcoriaceous. Length up to 20 centimeters. Maximum width up to 8.25 centimeters.

The petiole is very long and stout, curved, and enlarged at the base. Usually not preserved, it is complete in the Grand Coulee specimen and is about 6.5 centimeters in length, which is much longer than in most species of *Magnolia*. The midvein is stout and prominent. The secondaries are stout and prominent, 12 to 20 mostly alternate pairs, diverging from the midvein at angles of between 50 and 75°, generally rather straight proximad, becoming curved distad and eventually camptodrome. Tertiaries usually well marked comprising looped marginals and internal percurrent or forked veins at right angles to the secondaries and near the midvein subparallel with the secondaries both fading into an open more or less quadrangular areolation.

Knowlton thought that this species was an evergreen and this is possible although I can find no conclusive proof of this. He compared it with the living Magnolia foetida but it is less thick, less elliptical and has a longer petiole. It is more like the narrower leaves of the existing eastern Asiatic Magnolia obovata Thunberg which again has a much shorter petiole. Some of the forms from the Latah formation which have been referred to Laurus

grandis Lesquereux, as for example Knowlton's plate 24, figure 1, are certainly very similar to what is here called Magnolia spectabilis and I am not at all sure that they should not be transferred to the latter species. On the other hand specimens from the Latah which I have referred to Laurus grandis, as for example my plate 58, figure 3 appear to me to be lauraceous and quite distinct from Magnolia.

I have tentatively identified Magnolia Inglefieldi Heer from Grand Coulee and it is interesting to note that Knowlton compared Magnolia spectabilis with that species. The numerous specimens from the Arctic which Heer identified and figured as Magnolia Inglefieldi, if correct, show a wide range in size and form, and it is quite possible that the two magnolias from Grand Coulee represent the variants of a single botanical species.

Magnolia Inglefieldi Heer (?)

Magnolia Inglefieldi Heer, Fl. Foss. Arct. 1: 120. pl. 3. f. 5c; pl. 16. f. 5, 6, 8b; pl. 18. f. 1-3. 1868: Idem., 2: 478. pl. 44. f. 5b; pl. 51. 1871: Idem., 7: 121. pl. 69. f. 1; pl. 85. f. 3; pl. 86. f. 9. 1883.

Lesquereux, U. S. Natl. Museum Proc., 11: 13. 1888. Knowlton, U. S. Geol. Survey Bull. 204: 58. 1902.

Magnolia Inglefieldi was described by Heer in 1868 from a large number of fragmentary specimens collected by Capt. Inglefield at Atanekerd-luk in West Greenland. Additional specimens, including the cones, were figured in 1871 from collections made by Whymper. Additional specimens were figured in 1883 and altogether the species was recorded from five localities: Atanekerdluk, Ujararsusuk, Kudliset, Naujat and Asakak. These leaves show a considerable amount of variation and it is by no means certain that they all belong to a single species.

The one incomplete specimen and its counterpart from Grand Coulee is more like this species than any other that has been described, and is especially close to the specimen from Naujat, West Greenland, figured by Heer on plate 85 of the 7th volume of his Flora Fossilis Arctica.

Knowlton quotes Lesquereux for its identification in the Mascall beds of the John Day Basin in Oregon, but it is not contained in any of the collections except the early one made by Capt. Bendire and this material has never been figured so that it is impossible to say whether it is like the present specimens or some of Heer's smaller leaves. It is not unlike the modern *Magnolia acuminata* Linné, a mountain slope and stream bank type from western N.Y., southern Ontario, and southern Illinois to Kentucky, Tennessee, Alabama, Arkansas, and Mississippi. Most abundant and largest in mountain valleys of Tennessee and the Carolinas.

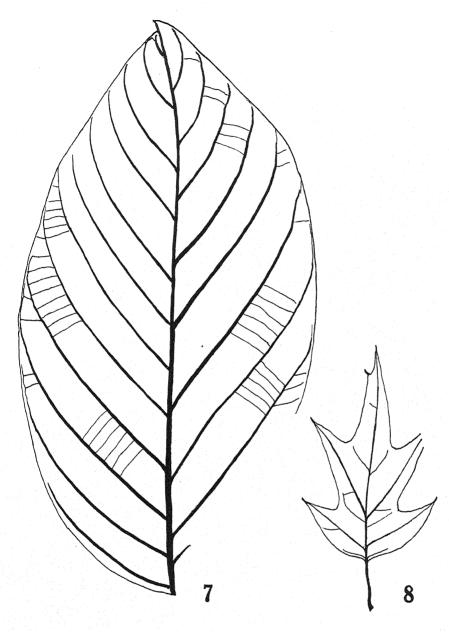


Fig. 7. Cornus Becki Berry, n. sp. Fig. 8. Quercus ursina Knowlton.

In shape and size and areolation it is very close to *Magnolia obovata* Thunberg (*M. hypoleuca* Sieb. & Zucc.) of Japan which, however, usually has the secondaries somewhat more closely spaced. This species occurs in the Pleistocene of Shiobara, Prov. Shimotsuke, Japan (Endo).

It is quite possible that what Knowlton⁴ called *Magnolia culveri* from the supposed Miocene of Yellowstone Park should be referred to this species.

Liquidambar californicum Lesquereux, emended

Figure 3

Liquidambar californicum Lesquereux, Harvard Coll. Mus. Comp. Zoology Mem. vol. 6²: 14. pl. 6. f. 7c; pl. 7. f. 3, 6. 1878.

Chaney, Walker Mus. Contr., 25: 174. 1920.

Berry, U. S. Geol. Survey Prof. Paper 154: 250. 1929.

Liquidambar europaeum Lesquereux, U. S. Geol. Survey Terr. Rept., vol. 8 (Cretaceous and Tertiary floras) 159. pl. 32. f. 1. 1883.

Liquidambar pachyphyllum Knowlton, U. S. Geol. Survey Bull. 204: 63. pl. 9. f. 1. 1902; U. S. Geol. Survey Prof. Paper 140: 42. pl. 22. f. 7; pl. 29. f. 1. 1926.

Chaney, Walker Mus. Contr. 25: 174. pl. 15. f. 2, 3. 1920.

A few years ago I suggested that there was but a single Miocene species of *Liquidambar* in the western United States. This was based upon the well known variation of the leaves of the modern species in size, relative proportions and degree of lobation. It may indeed be doubted if the Miocene species can be distinguished from the existing species by its foliar characters.

In my original account⁵ of the flora from Grand Coulee this species was not specifically recorded since the only traces of *Liquidambar* found were the fruits, which were found in both the brownish clays and in the diatomaceous boulders. These were not merged with the leaf species although it seemed obvious that both leaves and fruits belonged to a single botanical species. I also commented on the abundance of fruits at Grand Coulee and the absence of leaves. This deficiency has now been remedied since in the Beck collection from the brownish clays there is a medium sized three-lobed leaf and a small, incipiently five-lobed leaf. Since *Liquidambar* leaves are easily macerated it seems certain that the parent tree was not far removed from the place of fossilization and that the abundant fruits need not have been brought into the basin of deposition from any distance.

The smaller of the two leaves is figured in the present paper.

⁴ Knowlton, F. H., U. S. Geol. Survey Mon. 32: 720. pl. 92. f. 5. 1899.

⁵ Berry, E. W., U. S. Geol. Survey Prof. Paper 170 C, 1931.

Cornus Becki Berry n. sp.

Figure 7

Leaves of relatively large size, ovate in outline, slightly inequilateral, with the end of the midvein slightly recurved and the tip of the lamina slightly conduplicate. Margin entire. Length about 15 centimeters. Maximum width about 8 centimeters. Petiole not preserved. Midvein relatively narrow but prominent, usually faintly sigmoidally curved. Secondaries thin, prominent, 9 to 12 pairs; they diverge from the midvein at acute angles, are unequally spaced but subparallel, ascending in sweeping curves, terminating in camptodrome arches so close to the margins as to usually be indistinguishable. Tertiaries thin, mostly percurrent. Areolation indistinct. Named for the collector, George F. Beck.

There are a number of genera with leaves similar to these. The general shape and secondary pattern is not unlike *Diospyros* which is represented by splendid large fruits at Grand Coulee, but the tertiary venation is not that of *Diospyros*. Leaves similar to these are also often referred to *Ficus*, especially if they occur in the earlier Tertiary, and there is considerable resemblance to what Lesquereux called *Magnolia californica*, but again there are obvious differences in ascent and endings of secondaries and the character of the tertiaries.

Leaves of this sort from the older Tertiary are frequently referred to *Rhamnus* or *Rhamnites*, but I know of no Miocene or Recent species that are especially similar.

The totality of observed features are distinctly those of *Cornus* and the leaves of the existing western *Cornus Nuttallii* Audubon are not especially different except that they are usually considerably smaller. Our eastern arborescent dogwood, *Cornus florida* Linné although normally with smaller leaves does occasionally produce leaves as large as the fossil and these are scarcely distinguishable from it.

The geological history of *Cornus* goes back to the Upper Cretaceous. There are four species known from the western Miocene, two from California, one from Yellowstone Park and the fourth from the Latah formation at Spokane. The last, *Cornus acuminata* Berry is conspicuously different from *Cornus Becki*, being a narrow acuminate leaf like those of the living *Cornus canadensis* Linné.

Diospyros Andersonae Knowlton

Figures, 4, 5

Diospyros Andersonae Knowlton, U. S. Geol. Survey Prof. Paper 140: 46. pl. 27. f. 6. 1926.

⁶ Lesquereux, L., Mus. Comp. Zool. Mem. 6: 25. pl. 6. f. 6, 7. 1878.

This fine calyx was described by Knowlton from a specimen found in the Latah formation exposed in a cut on the Spokane, Portland and Seattle Railway in Spokane. It was naturally compared with the calyx of the living persimmon of southeastern North America—Diospyros virginiana Linné from which it differed in merely minor details. It was evidently not often fossilized in the Latah sediments as I have not seen it in the large amount of material that I have studied from the Spokane region, but this can not be taken to indicate that the parent tree was rare, since the Latah contains large numbers of leaves of a Diospyros which I have called Diospyros princetoniana Cockerell and which presumably represents the same botanical species as the calyx.

In the diatomaceous clay from Grand Coulee there is a very fine specimen of a persimmon calyx, which can hardly represent other than this same species. It is slightly larger than the type but is identical with it in general features, texture, etc., differing from it in having five instead of the normal four calyx-lobes. The number of these lobes can not be considered a specific character since five occur occasionally in both our existing American and in Asiatic forms.

Although the present fossil is very similar to the calyx of *Diospyros virginiana* this similarity does not impress me as strongly as it did Knowlton and in particular the shape and venation of the lobes is more similar to the Asiatic cultivated form.

Of the greatest interest is the occurrence of an unmistakable seed of Diospyros about one-quarter of an inch away from the calyx and at a level about one-eighth of an inch removed from it. This seed is almost exactly the size, shape and has the papillated surface of the seeds of Diospyros virginiana and probably came from the same fruit that furnished the calyx. Under the circumstances it seems to me that it would be absurd not to consider the seed as belonging to the same species.

⁷ Berry, E. W., U. S. Geol. Survey Prof. Paper 154: 263. pl. 59. f. 6; pl. 60. f. 1–3. 1929.

Studies in the Ericales III. The genus Leiophyllum

W. H. CAMP

During the identification of certain specimens of Leiophyllum¹ collected by the writer in New Jersey in 1933 and the southern Appalachians in 1936, a critical review of this eastern North American genus seemed advisable. It was soon apparent in the study of the three species (L. buxifolium, L. Lyoni, and L. Hugeri) which are sometimes recognized as those of which the genus is composed, that certain of the specific distinctions which had been emphasized in the past were of little phylogenetic significance and of still less taxonomic convenience.

The distribution of the genus is interesting, for it ranges from certain of the higher summits of the Smokies and the Blue Ridge in Tennessee and North Carolina, across the states of North and South Carolina (several disjunct stations) to the coast, where it is known from the region near Cape Fear. From here there is a jump of nearly 450 miles to the next nearest station in the pine-barrens of New Jersey where it is fairly common, and in local areas even abundant.

Much has been written concerning the distribution of genera and species limited to the southern Appalachians and the coastal plain in the region of the New Jersey pine-barrens. It, therefore, will be unnecessary to review the literature at this time. Since the genus under consideration—as its eight to twelve sister genera in the Phyllodoceae of the Ericaceae—is obviously a remnant of the Late Mesozoic and Early Tertiary dispersal of the heath family, it will be essential only to outline the probable distribution of the genus *Leiophyllum* in the Tertiary.

It is becoming increasingly doubtful in the mind of the writer whether many of the genera or species endemic on the peaks of the southern Appalachians really originated there. It is more likely that their evolution took place either in the earlier highlands slightly to the southeast, or in other regions, and that their occurrence on the backbone of the present mountain system is to be explained on the basis of relic colonies of a once more widely dispersed group. It is a truism that endemism is common on

¹ Leiophyllum (Pers.) Hedw. fil. Gen. 313. 1806, is to be preferred over Dendrium Desv. Jour. de Bot. II. 1: 36. 1813. It is not preoccupied by Leiophyllum Ehrh. 1789, which is without description and invalid and admitted by Ehrhart himself to be without standing as a generic name. Points in the bibliography of this genus have been discussed by Barnhart (Rhodora, 22: 180–182. 1920) and Fernald (Rhodora, 29: 225–227. 1927). Dr. Barnhart and the present writer, on the basis of copies of the "Journal" in our own library, are unable to agree with Professor Fernald on his citation for Dendrium, maintaining that the one given above is the more correct. In any event, we all agree that Leiophyllum is the correct name.

many mountain systems, but this fact does not necessarily lead to the conclusion that "mountains make species." It is the contention of the writer that mountains capture aggressive genetic biotypes and because of their isolation and variations in altitude and habitat, tend to conserve these biotypes during subsequent climatic and floristic disturbances. A relatively small change in elevation or climate is sufficient to change the whole floristic aspect of a piedmont or lowland region and eliminate many of the species represented in it, whereas the same variation might require the plants on a favorably situated and contiguous mountain area to migrate only a few hundred feet in altitude to come to rest in habitats suitable for their preservation.

It seems, therefore, to the writer that, in the Early Tertiary, the genus Leiophyllum was more widely distributed than at present on what is now the piedmont of the southern Appalachians and that this region was the home of the basic species. During the climatic changes and orogeny of the Tertiary, two easy avenues of migration were open. One was into the mountain systems to the northwest undergoing a cycle of secondary elevations; the other was to the coastal plain. Both of these migrations evidently took place.

The basic species of Leiophyllum apparently was a plant sometimes in excess of a meter in height with mostly alternate, longish leaves inclined to be apically obtuse to acute, or at least apiculate, and bearing stalked glands on its flower and fruit pedicels. The biotype which originated in, or possibly near, and later migrated onto the present higher mountains, differed in being somewhat more spreading, and particularly in having its leaves mostly opposite, more oval, or sometimes suborbicular, apically rounded and rarely apiculate. The early range of this mountain form probably was reduced by the climatic changes of the Late Pliocene and the Pleistocene.

When the basic species migrated to the then periodically broader coastal plain, its biotypes found there an environment which was remarkably uniform for a stretch of almost 700 miles from the Carolinas to the deep Tertiary valley of the Hudson River. This rather wide and probably common distribution of the plant in question was destined to be comparatively short-lived, for the series of submergences of the coastal plain during the Middle and Late Tertiary apparently eliminated the plant between Cape Fear and Cape May. During one of these later submergences (the Pensauken?) the present pine-barren region of New Jersey, for a time, was probably isolated from the mainland. It was the incomplete submergence of this area, together with its peculiar soil conditions, which permitted so many of the southeastern coastal plain species and those of peculiar habits which had wandered there from the piedmont and mountains, to find refuge from a too severe competition and thus escape elimination.

The type of the genus [Leiophyllum buxifolium (Berg.) Ell.] undoubtedly was collected in New Jersey and for a long time the material from this region has been supposed to be easily differentiated from the mountain forms by the absence of glandular hairs on its flower and fruit pedicels and in part on leaf arrangement. (It is the opinion of the writer that other of the flower and fruit characters often used are of too fluctuating a character to be reliable.) However, a careful examination of material from the New Jersey localities revealed, in certain areas at least, that the pedicels of a considerable number of the plants bore gland-hairs. At the same time it was noted that the bracts, and particularly the pedicels of the eglandular material were somewhat more glaucescent than the same parts of those plants whose pedicels were glandular. These plants with gland-bearing pedicels were obviously very closely related to the material found eastwards from the mountains and on the coast of North Carolina, all of which undoubtedly represent remnants of the once more widely dispersed basic species.

It is thought that the eglandular material from New Jersey represents a mutant form which was abundant on the relatively small island off the coast during the Pensauken (?) submergence; a form so common in that peculiar area that even to the present it constitutes a large proportion of the specimens seen. A recently studied collection from Springville (near Darlington), South Carolina (P. H. Rogers, April 10, 1912), contained a little material approaching the eglandular form found in New Jersey. It is therefore possible that both forms might have been present throughout the entire coastal plain range of the genus. At least, they should not be thought of as being distinct species.

The problem of matching names and specimens is not an easy one. The abundant material from New Jersey, the pedicels of which are eglandular, is consonant without ideas of Leiophyllum buxifolium var. typicum C. K. Schneider. The opposite-leaved material from the mountain summits is harder to place. The oldest name which is available is Leiophyllum Lyoni Sweet. The original description, however, consists of a single word: "spreading". In the absence of a type specimen, this inadequate description gives us considerable latitude and it has been the custom of some of the more recent writers to assign this name only to the occasional prostrate forms found on certain of the mountain summits. A study of these forms indicates that they are not separable from the rest of the highmountain material and are probably the result of environment. L. Lyoni, therefore, should be used for the more common mountain plant.

During the course of this investigation it was found that most of the collections assigned to *Dendrium Hugeri* Small, 1901 (*L. Hugeri* Schneider, 1903. *L. buxifolium* var. *Hugeri* Schneider, 1911.) were not conspecific with the type specimen, but belonged to the group of plants defined by the

present writer as L. Lyoni. The reduction of Hugeri to a variety was, for Schneider, a blind, but fortunate decision. If one may judge by the specimens seen from foreign gardens, his further statement that Hugeri is the common form in cultivation in Europe, clearly indicates that he was certainly less aware of its correct relationships than the original author of the species and surely ignorant of the type specimen and the material from the piedmont.

The type of *Hugeri* is unfortunate for, although it belongs with the material forming the basic species, it is an extreme specimen and may in part be contaminated with the heredity of *Lyoni*. While it must remain as the "nomenclatorial type" it is not to be regarded as biologically typical. It is thought best, however, rather than inject a new name into our taxonomic literature (since this particular specimen could be included as an extreme) to retain *Hugeri* as the name for the fundamental biotype of the genus. Unfortunately, because of present rules, the basic entity must take subordinate nomenclatorial rank for I am unable to discern more than a varietal difference between *buxifolium* and *Hugeri*. Because of its differences in phyllotaxy² and leaf form from *L. buxifolium* vars. *typicum* and *Hugeri*, the writer maintains *L. Lyoni* as a distinct species.

It is to be admitted that, during the course of this study, various minor biotypes based on pedicellary puberulence, leaf form and flower structure were observed, some of them with remarkably stable characters which obviously were the result of local endemism. I feel, however, that the addition of a whole series of new subspecific names to our North American ericaceous literature is at present neither necessary nor advisable. The picture of the genus presented here seems, in my opinion, to be taxonomically sufficient to take care of the known material and in addition gives a working hypothesis of the origin and migrations of the various recognized entities in the genus.

The following key and list of localities, with specimens cited fully only in the case of var. *Hugeri*, summarizes the writer's present knowledge of the genus.

KEY TO THE GENUS LEIOPHYLLUM

Leaves mostly alternate, longish and apiculate.	
Pedicels eglandular	L. buxifolium var. typicum.
Pedicels glandular	L. buxifolium var. Hugeri.
Leaves mostly opposite, elongate-oval to orbicular an	d apically rounded, rarely apiculate
그 그 그는 발생 내 지금 보다 가지 않는데 그 모든데 그 모든데 그 없는데 그 없는데 그 없는데 그 없다.	I. I.voni.

² In the Ericaceae, the occurrence of opposite leaves is a departure from the normal and points to evolutionary specialization. This particular character is not a completely fixed habit in *L. Lyoni* and in rapidly growing stems the phyllotaxy may occasionally revert to alternate, indicating its close relationship with and derivation from var. *Hugeri*. Conversely, dwarfed and stunted branches of *buxifolium* vars., may sometimes bear nearly opposite leaves.

LEIOPHYLLUM BUXIFOLIUM var. TYPICUM C. K. Schneider.

NEW JERSEY. ATLANTIC: Hammonton; Landisville. BURLINGTON: Atsion; Batsto; Chatsworth; Marlton; New Lisbon; Quaker Bridge; Woodmansie. Camden: Waterford. Monmouth: Freehold. Ocean: Forked River; Lakehurst; Manchester; Toms River; Waretown; Whitesville; between Warren Grove and Symmes Place.

LEIOPHYLLUM BUXIFOLIUM var. HUGERI (Small) C. K. Schneider.

SOUTH CAROLINA. DARLINGTON: Springville (near Darlington) along sandy banks and sand hills of Black Creek, P. H. Rogers Apr. 10, 1912 (in part tending toward var. typicum); Darlington, T. G. Harbison 18 Dec. 18, 1918; ibid. T. G. Harbison 33 Nov. 22, 1919. Pickens: Table Mt., J. K. Small Aug. 1896 (Type); ibid. Buckley (Ex. Herb. Geo. Thurber). This specimen lying in the Gray Herbarium agrees almost exactly with the type.

NORTH CAROLINA. AVERY: Cañon of Linville River, John McRae Sept. 1896. (Mitchell Co. on label). Brunswick: Wilmington to Southport, W. C. Coker Apr. 6, 1918; 12 mi. from Southport, W. C. Coker and party May 15, 1926; north of Southport, E. B. Bartram Jan. 28, 1922; Orton Plantation, 15 mi. n.e. of Southport, A. C. Matthews Apr. 9, 1935; 4 mi. e. of Bolivia, J. M. Fogg, Jr. 5492 Apr. 16, 1933; without locality, M. A. Curtis. Burke: Wiseman's View, Linville Mts. Alexander, Everett and Pearson Oct. 10, 1933; Ervin's View, Linville Falls, Anne R. Clement June 17, 1934; ibid. "Irwin's View," above Linville Falls, W. C. Coker Sept. 10, 1927. Caldwell: Hibriten Mt., near Lenoir, A. M. Huger Sept. 1896. Cumberland: Cultivated at Red Springs but taken from plants said to be "plentiful" near Fayetteville, Mary Vardelle Apr. 1923. New Hanover: "Cape Fear" near Wilmington, E. J. Palmer 39825 Apr. 12, 1923. Stokes: Piedmont Springs, L. Barksdale Apr. 29, 1934; Cascade Falls near Piedmont Springs, H. R. Totten May 12, 1929.

NEW JERSEY. ATLANTIC: Egg Harbor, J. B. Brinton May 18, 1890. Burlington: Chatsworth, E. H. Eames June 14, 1894; ibid. J. T. P. Byhouwer and C. E. Kobuski 80 May 25, 1928; Pemberton, L. H. Lighthipe May 27, 1884. Camden: near Albion, U. B. Meredith June 7, 1924; Sumner, A. Haines 311 June 2, 1906; without locality, C. F. Parker June 2, 1867. Ocean: without locality, P. Birdsall May 15, 1891; Forked River, J. R. Churchill May 27, 1891 (in part); Manchester, N. L. Britton Aug. 28, 1879; ibid. J. W. Chickering, Jr. July 19, 1873; ibid. (without collector) "Ex Herb. Torr." May 16, 1870; Toms River, P. Wilson July 3-5, 1916; ibid. J. I. Northrop May 30, 1887; ibid. A. B. Clute May 27, 1888; ibid. W. W. Eggleston May 30, 1907.

LEIOPHYLLUM LYONI Sweet.

TENNESSEE: SEVIER: Great Smoky Mts. Nat'l. Park, Mt. Leconte; The Chimneys.

TENNESSEE and NORTH CAROLINA. Line between CARTER Co., TENN. and MITCHELL Co., N. C.; Roan Mt.

NORTH CAROLINA. AVERY: Northeast of Linville; Banners Elk. Line between AVERY and WATAUGA: Grandfather Mt. BURKE: Table Rock Mt. Line between HAYWOOD and TRANSYLVANIA: Devil's Court House. JACKSON: Whitesides Mt.; Sapphire. MACON: near Highlands; ibid. top of Satulah Mt.; ibid. Sunset Rocks; Mt. Whiteside; "Crest of the Blue Ridge." McDowell: Shortoff Mt., near Marion.

During the course of this study the writer examined all available specimens of the genus in the Herbarium of the University of North Carolina, Herbarium of the Arnold Arboretum, Gray Herbarium, U. S. National Herbarium and the Herbarium of the New York Botanical Garden.

THE NEW YORK BOTANICAL GARDEN

Studies in Onagraceae XI. A revision of the genus Gaura

PHILIP A. MUNZ
(WITH EIGHTEEN FIGURES)

During the past several years I have had opportunity to visit much of the area in which Gaura is distributed and to work in many of the herbaria in which types are deposited. Among these herbaria are those at British Museum (BM), Bossier Herbarium (Boiss), Delessert Herbarium (Del), Edinburg (Edin), Kew(K), and Paris (P). In addition to types above mentioned, I have had for study the material at Gray Herbarium (G), Herbarium of New York Botanical Garden (NY), Pomona College (P), and at the United States National Herbarium (US). To all those in charge of the above institutions I gladly express my gratitude. I wish particularly to acknowledge my indebtedness to Mr. V. L. Cory of Sonora, Texas, whose abundant collections of Onagraceae in that state have been most helpful to me.

In this paper I am using the word Gaura in the same sense as that of Bentham and Hooker, Rothrock, and Engler & Prantl, namely excluding Stenosiphon, Heterogaura, and Gonglyocarpus. For the sake of space, I shall not here present any opinions on phylogeny and relationship, which are being reserved for a future paper on the whole family.

GAURA L.

Gaura, L., Nov. pl. Gen., 47, 1751; Amoen. Acad. 3: 26. 1756. Endlicher, Genera Pl., no. 6131, 1836–'40. DeCandolle, Prodromus 3: 44. 1828. Rothrock, J. T., Proc. Amer. Acad. 6: 349. 1864. Benth. & Hooker, Genera Pl. 1: 792. 1867. Raimann in Engler & Prantl, Die Nat. Pflanzenfam. III, 7: 218. 1898.

Gauridium Spach, Hist. Vég. Phan. 4: 379. 1835.

Schizorcarya Spach, Ann. Sci. Nat. Sér. II, 4: 170, 283. 1835.

Flowers white to pink (yellow in one species), in spicate to subcapitate racemes, more or less symmetrical, usually irregular, 4-merous, sometimes 3-merous. Hypanthium obconic or cylindrical. Stamens twice as many as the petals, declined, all fertile, each usually with a scale at the base of the filament. Stigma more or less deeply 4- (3-) lobed, and provided at the base with a cuplike indusium. Ovary 4- (3-) locular, or partition obsolete; ovules solitary or rarely 2 in the locules. Style filiform, deflexed. Fruit woody, small, 4- (3-) sided, indehiscent, sometimes 4- (3-) cleft apically, 4- (3-) seeded or 1-seeded by abortion. Annual or perennial herbs, rarely suffruticose.

Type species,—G. biennis. L.

KEY TO SPECIES

A. Capsule sessile or nearly so, not narrowed into a pedicel-like base, except sometimes in brachycarpa and gracilis.

- B. Petals yellow, aging red, subequal, rhombic, 14-15 mm. long; hypathium 25-35 mm. long; sepals 15-18 mm. long. Mexico.

 1. G. mutabilis. 1
- BB. Petals white to pink or red, in 2 pairs (1 more or less erect, the other spreading to the side); hypanthium 1-12 mm. long; sepals 1.5-15 mm. long.
 - C. Flowers small; petals 1.5-2 mm. long; sepals 1.5-3 mm. long; anthers oval, 1 mm. long.

 2. G. parviflora.
 - CC. Flowers larger; petals 3-20 mm. long; sepals 4-15 mm. long; anthers oblong to linear, 2-5 mm. long (1 mm. in angustifolia).
 - D. Fruit with rounded or obtuse angles, pubescent, more or less fusiform.
 - E. Hypanthium 5-7 mm. long; fruit 4-7 mm. long. E. Texas & Okla. to Ia. & Atlantic coast.

 3. G. biennis.
 - EE. Hypanthium 8-12 mm. long; fruit 7-15 mm. long.
 - F. Sepals 9-11 mm. long; petals 8-10 mm. long; filaments 8-10 mm. long. New Mex. & Colo.
 4. G. neomexicana.
 - FF. Sepals 6-7 mm. long; petals 5 mm. long; filaments 3-4 mm. long. W. Texas. 5. G. macrocarpa.
 - DD. Fruit sharply angled.
 - E. Sepals 12-15 mm. long; petals 12-20 mm. long; filaments 10-15 mm. long. S. E.
 Texas and adjacent La. & Mex.
 6. G. Lindheimeri.
 - EE. Sepals 4-10 (12) mm. long; petals 4-10 mm. long; filaments 3-7 mm. long.
 - F. Fruit 3-angled; flowers 3-merous.
 - G. Plant usually simple below, 6-18 dm. tall; petals 4-6 mm. long; fruit elliptic to ovoid, the faces not transversely wrinkled. Car. to Fla. & Ala.
 - 7. G. angustifolia.
 - GG. Plant usually branched from base, 2-6 dm. tall; petals 3-4 mm. long; fruit pyramidal, the faces transversely wrinkled. Okla. to Mex. 12. G. tripetala. FF. Fruit 4-angled; flowers 4-merous.
 - G. Sepals 4–7 mm. long (sometimes 8 in brachycarpa.)
 - H. Fruit pyramidal, tapering from base upward; anthers 2 mm. long. Texas to Mex. and Ariz.
 - I. Sepals 4-5 mm. long; cauline leaves 1-3 mm. wide; wings of fruit not auricled at base.
 10. G. gracilis.
 - II. Sepals 6-7 (8) mm. long; cauline leaves 5-12 mm. wide; wings of fruit auricled at base.
 11. G. brachycarpa.
 - HH. Fruit ovoid to elliptic, somewhat narrowed at both ends; anthers 1 mm. long. Car. to Fla. and Ala. 7. G. angustifolia.
 - GG. Sepals 8-10 (12) mm. long.
 - H. Inflorescence canescent-strigulose to villous; anthers 2.5-3 (4) mm. long. 8. G. filiformis.
 - HH. Inflorescence glabrous; anthers 4-5 mm. long.

 9. G. suffulta.
- AA. Capsule narrowed into a distinct thick or slender stipe-like base.
 - B. Stipe-like base of capsule very slender (almost filiform), the capsule-body being abruptly narrowed at base.
 - C. Plant soft-villous with long hairs; stipe-like base of fruit 3-6 mm. long; petals 8 mm. long. Kansas to Texas & New Mex.
 13. G. villosa
 - CC. Plant pubescent to glabrous; stipe-like base 1-3 mm. long; petals 4-6 mm. long. East of Mississippi River.
 - D. Capsule obovoid-clavate, the stipe-like base mostly 1.5-3 mm. long. 14. G. filipes.
- ¹ For the species *G. mutabilis* I accept the section *Gauridium* (Spach) Endlicher, Gen. Pl. no. 6131. The other species I would include in the section *Eugaura* n. nom. with white to pink, somewhat irregular flowers.

DD. Capsule elliptic to narrowly ovoid, the stipe-like base 0.5-1 mm. long.

7. G. angustifolia.

- BB. Stipe-like base of capsule stout, the capsule-body being more gradually narrowed at the base.
 - C. Hypanthium and sepals with minute gland-tipped hairs; stipe-like base of fruit 1-1.5 mm. long; face of fruit transversely wrinkled. W. Texas to Ariz.
 15. G. Nealleyi.
 - CC. Hypanthium and sepals not glandular; stipe-like base of fruit 2-5 mm. long; face of fruit not transversely wrinkled.
 - D. Hypanthium 2.5-4 mm. long; filaments 8-10 mm. long; fruit 5-9 mm. long, 1-1.5 mm. wide. Okla.-Mex.

 16. G. sinuata.
 - DD. Hypanthium 5-12 mm. long; filaments 3-6 mm. long.
 - E. Fruit 1.5-2 mm. wide, 10-15 mm. long, narrowly fusiform, sometimes curved, ribbed but not angled. Western Texas and adjacent Mex. 5. G. macrocarpa.
 - EE. Fruit mostly 2-3 mm. wide, the ovoid body 4-angled and rather rapidly narrowed basally into a terete obconic stipe.
 - F. Sepals 10-13 mm. long; petals 7-8 mm. long; floral bracts lance-ovate, caducous.

 Texas to southern Mex.

 17. G. odorata.
 - FF. Sepals 5-9 mm. long; petals 3-6 mm. long; floral bract lanceolate to linear, mostly persistent. Alberta to central Mex. 18. G. coccinea.

TREATMENT OF SPECIES

1. GAURA MUTABILIS Cav., Icon. 3: 30, pl. 258. 1795.

Gauridium mutabile Spach, Hist. Vég. Phan. 4: 380. 1935; Nouv. Ann. Mus. Paris (III) 4: 374. 1835. Oenothera anomala Curtis, Bot. Mag., pl. 388, 1797. Gaura mollis HBK., Nov. Gen. et Sp. 6: 93, pl. 529. 1823. Gauridium molle Spach, Hist., 1. c. G. Kunthii Spach, Nouv. Ann., 1. c. 375. Gaura oenotherifolia Zucc., in Roemer, Collect., 140, 1809. G. canescens Hort., ex Ser. in DC., Prodr. 3: 45. 1828. Oenothera Héribaudi Léveillé, Fedde Repert. Nov. Sp. 8: 280. 1910.

Perennial herb from heavy rather woody caudex, bushy, much branched throughout, 3-6 dm. high, short- and soft-villous throughout; leaves well distributed in lower half or two-thirds of plant, the basal ones oblanceolate to spatulate in outline, 4-8 cm. long, 8-20 mm. wide, sinuate-dentate especially on the winged petiole; cauline leaves lanceolate to ovate, acute, sinuatedenticulate, almost or quite sessile, gradually reduced up the stem, mostly 2-4 cm. long and 5-20 mm. wide; inflorescence with deciduous lance-ovate bracts 3-4 mm. long, not peduncled, elongating in fruit to 1-2 dm., spicate; buds erect; flowers opening in evening; hypanthium slender, pubescent without 25-35 mm. long, often somewhat reddish, short-retrorse-pubescent within; sepals with some red, pubescent, 15-18 mm. long, lanceolate, more or less adherent in anthesis, without free tips; petals rhomboid, yellow in anthesis, orange-red in age, quite equal, 14-15 mm. long; stamens yellowish, slightly unequal, equalling or exceeding petals, the filaments slightly flattened, glabrous, with no evident basal scale; anthers linear, 4-5 mm. long; style exserted well beyond stamens, 4-6 cm. long from summit of ovary, retrorse-pubescent at very base; stigma-lobes linear, 2-3 mm. long; capsules fusiform, sometimes curved, 4-nerved and obtusely 4-angled, usually pubescent, 7-14 mm. long, 2-4 mm. thick, 1-few-seeded; seeds flattened, brown, overlapping smooth.

Type locality, "Habitat in Nova-Hispania." Well distributed in Mexico. Representative material: without locality, Jardin du Luxembourg, in 1822, "graines envoyées por Lagasca" (K photo at P); "G. mutabilis m. Lagasca, 1806," Prodromus Herb. (Del); "G. oenotheriflora Zucc. m. Balbis, 1808," Prodromus Herb. (Del); G. mollis, Herb. Humboldt & Bonpland (Paris). CHIHUAHUA: Chihuahua, Pringle 1125 (G, US); between Cusihuiriachic & Guerrero, Pringle 1244 in part (NY). DURANGO: Otinapa, Palmer 460 (G, US); El Salto, Nelson 4570 (P, US). GUANAJUATO: Guanajuato, Dugès 6 (G), 303 (G). DISTRITO FEDERAL: Pedrigal, Pringle 6661 (G, NY, US); Santa Fé, Rose & Painter 6504 (G, NY, US), Borgeau 296 (G, US). HIDALGO: Marquez, Pringle 7635 (P, photo US). PUEBLA: San Luis Tultitlanapa, Pur pus 3388 (G, NY, US); Bord del l'Alsesécon, Nicolas in 1909, Oe. Héribaudi (Del, US, photo at P), in 1910 (Edin, US). OAXACA: without locality, Andrieux (G, Del).

The specimens cited above are pubescent in the inflorescence, while the following are characterized by a glabrous inflorescence and may be designated as forma glabra n. nom. (synonym, G. grandiflora Rose, Contrib. U. S. Nat. Herb. 12: 293. 1909): CHIHUAHUA: between Cusihuiriachic & Guerrero, Pringle 1244 in part (G, NY, US). DURANGO: Durango, Palmer 270 (G, US) and (NY in part); Papasquiaro, Nelson 4671, type grandiflora (US). The lack of pubescence is not definitely enough correlated either with distribution or any morphological characters to warrant more than such rank.

There might be some argument for recognizing the genus *Gauridium*, since this species is the only yellow-flowered one and the base of the filaments lacks a scale. But such scale is not found in *Guara parviflora* and color alone with perhaps a more regular flower hardly seems to warrant generic rank.

2. GAURA PARVIFLORA Dougl., ex. Hooker, Fl. Bor. Am. 1: 208. 1834.

Apparently a biennial or winter annual, from 2–20 (30) dm. tall, erect, rather simple below, simple or more commonly freely and widely branched above, soft-villous almost throughout with spreading white hairs, also with shorter glandular ones; leaves soft-pubescent, simple, alternate; rosette leaves typically broadly oblanceolate, 5–15 cm. long, 1–3 cm. wide. remotely sinuate-denticulate, the blade proper gradually narrowed into winged petioles; cauline leaves gradually reduced upward, almost or quite sessile, entire or remotely sinuate-denticulate, lanceovate to lanceolate, acuminate to acute, 3–10 cm.

long, 1–2.5 (3.5) cm. wide; bracts lance-linear, 2–5 mm. long, caducous; flowers opening in evening, in terminal slender spikes which usually nod at tips and become 1–3 dm. long; hypanthium 1.5–3 mm. long, slender, glabrous to short-pubescent without, pubescent within; sepals greenish to reddish, 1.5–3 mm. long, oblong-lanceolate, reflexed separately in anthesis, glabrous to puberulent; petals spatulate, mostly pink or rose, 1.5–2 mm. long, erect, slightly clawed; stamens slightly shorter than sepals, basal scale obsolete; filaments rose, flattened, the episepalous slightly longer than epipetalous; style reddish, projecting about as far as sepal-tips, usually pubescent on basal portion (inside hypanthium); anthers reddish, ca. 1 mm. long, oval versatile; stigma with 4 short white lobes scarcely exserted from its reddish lobed cup; capsule sessile, 6–10 mm. long ca. 2 mm. thick, somewhat fusiform in outline, narrowed at base, 4-nerved, obtusely 4-angled above; seeds 1–2, brown.

KEY TO VARIETIES

Ovary and capsule glabrous	
Hypanthium minutely puberulent	2a. G. parviflora var. typica
Hypanthium glabrous	2b. forma glabra
Ovary and capsule short-pubescent	2c. var. lachnocarpa

2a. G. parviflora Dougl. var. typica n.nom.

G. parviflora Dougl. ex Hook., Fl. Bor. Am. 1: 208. 1834. Schizocarya micrantha Spach, Ann. Sci. Nat. II, 4: 283. 1835. Gaura micrantha D. Dietr., Syn. Pl. 2: 1297. 1840. G. mollis Nutt. ex Torr., Ann. Lyc. N. Y. 2: 200. 1828, not HBK. in 1823.

Hypanthium puberulent, 2-3 mm. long; sepals 2-3 mm. long, mostly glabrous, sometimes puberulent; ovary and capsule glabrous.

Type locality, "Sandy banks of the Wallawallah River, North-west coast of America." Grows best as a ruderal and is common in waste and disturbed places over a large area from eastern Washington to the Mississippi Valley and northern Mexico. Sometimes introduced farther east: MASS.: Cambridge, Morong in 1886 (NY); INDIANA: Michigan City, Mell 111 (US); ILLINOIS: Romeo, Umbach in 1897 (US). Other representative material, Rocky Mts., Nuttall (K, NY). MISSOURI: Joplin, Palmer 2591 (G, NY, US). SO. DAK.: Deadwood, Murdoch 4331 (G, NY). NEBRASKA: Minden, Hapeman in 1928 (P); St. James, Clements 2632 (G, NY). KANSAS: Manhattan, Norton in 1892 (NY); Osborn City, Shear 145 (G, P, US). OKLAHOMA: Bridgeport, Munz 13577 (P); Calvin, Munz 13574 (P). COLORADO: Denver, Jones 656 (NY, P); Naturita, Payson 118 (G). WYOMING: Gardiner River, Yellowstone Nat. Park, A. & E. Nelson 5986 (G, NY, US); Two Bar Ranch, Blue Grass, Nelson 376 (G, NY, US). IDAHO: King Hill, Elmore Co., Nelson & Macbride 1096 (G, NY, P, US); Falk's Store, Canyon Co., Macbride 329 (G, NY, US). WASHINGTON: low banks of Walla Walla River, Douglas, Herb. Hookerianum (K, photo at P); Wawawai, Whitman Co., Elmer 898 (NY, P, US). OREGON: Snake River bottom, Union Co., Cusick 939 (G); The Dalles, Peck 9916 (P). NEVADA: Battle Mt. Hitchcock 613 (US). UTAH: Springdale, Jones 5256 (NY, P, US); Parley's Canyon, Wasatch Mts., Stokes in 1900 (NY, US). ARIZONA: Navaho Reservation, Vorhies 120 (G, NY); Chiricahua Mts., Blumer 1776 (G, NY, US). NEW MEXICO: Farmington, San Juan Co., Standley 6924 (US); Albuquerque, Jones in 1884 (P). TEXAS: Jeff Davis, Cory 2138 (P). S. Felipe de Austin, Drummond 46, type coll. of Schizocarya micrantha (Del, G, NY); Del Rio, Jones 25877 (P). CHIHUAHUA: Chihuahua, Palmer 190, in part (G, NY, US), SONORA: Cochuto, Hartman 96 (G, NY, US).

Intergrading freely with both of the following:

2b. G. parviflora var. typica forma glabra new form.

Hypanthium glabrous, 2-3 mm. long; sepals glabrous, 2-3 mm. long; ovary and capsule glabrous. (Hipantium glabrum, 2-3 mm. longum; sepalis glabris, 2-3 mm. longis; ovario capsulaque glabris).

Type, Deer Run, west central Colorado, Baker 94, June 11, 1901, at 4700 ft., Pomona College Herbarium No. 32745; isotypes at Gray, New York, U. S. Ranging more or less widely with var. typica. Representative material, MISSOURI: St. Louis, Sherff 405 (G); Joplin, Palmer 2494 (G). OKLAHOMA: Hollis, Harmon Co., Stevens 1100 (G, NY). TEXAS: Weatherford, Tracy 7822 (G, NY, US); San Antonio, Clemens 695 (NY, P). LOUISIANA: Mississippi banks, Langlois 96 (NY). NEBRASKA: Calahan, Williams in 1889 (US). KANSAS: Wichita, Smyth 236 (US). COLO.: Durango, Baker, Earle & Tracy 493 (G, NY, P, US). NEW MEXICO: Ft. Bayard Watershed, Grant Co., Blumer 72 (G, NY); Kingston, Sierra Co., Metcalfe 1241 (G, NY, P. US). ARIZONA: Ramsay Canyon, Huachuca Mts., Jones 24941 (P). Some collections show complete intergradation of this rather trivial form with var. typica, for example Metcalfe 159, Mangas Springs, N. M. (G, NY, P, US) and Earle 230 from Lincoln, N. M. (NY).

2c. G. Parviflora Dougl. var Lachnocarpa Weatherby, Rhodora 27: 14, 1925.

G. australis Grisebach, Goett. Abh. 24: 132. 1879.

Hypanthium 1.5–2.5 mm. long, with short mostly divergent pubescence; sepals 1.5–2 mm. long, strigulose or with divergent puberulence; capsule with divergent pubescence.

Type locality, Austin, Texas. With a more southern range than that of var. typica, although with some overlapping, it occurs from Missouri and

Utah to Mexico, also in Argentine. Representative material, MISSOURI: Courtney, Bush 7738 (G, NY). ALABAMA: Montgomery, Harper in 1924 (G, NY, US), very possibly an introduction. TEXAS: Austin, Young 95, type (G), E. Hall 216 (G, NY, P, US); Kerrville, Heller 1768 (G, NY, US); Belmont, Gonzales Co., Munz 13338 (P). NEW MEXICO: Mesilla, Crozier in 1897 (G). ARIZONA: Casa Grande, Loomis 1160 (P); Colorado Valley near Ft. Mojave, Cooper in 1860-'61 (G, US). UTAH: Salt Lake City, Jones 1460 (NY, P, US); St. George, Craig 1398 (P). BAJA CALIFORNIA: San José del Cabo, Anthony 330 (G, P, US); Todos Santos, Jones 24137 (P); Muleje, E. Palmer 11, in 1887 (G, US). SONORA: Hermosillo, Rose, Standley & Russell 12465 (NY, US); Alamos, Rose, Standley_& Russell 12961 (NY, US). CHIHUAHUA: Lake Santa Maria, Nelson 6406 (US). COAHUILA: Saltillo, E. Palmer 213, in 1898 (G, NY, US). DURANGO: Durango, E. Palmer 102, in 1896 (G, NY, US). SINALOA: Culliacan, Rose, Standley & Russell 14867 (NY, US). ARGENTINE: Sierra de Córdoba, Capilla del Desierta, Barros in 1925 (G); Sierra Chica, Córdoba, Lossen 226 (G); Sierra Grande, Córdoba, Burkart 7328 (P); between Mina Argentia u Yerbabuena in foothills of Cerro de Oroosu, Córdoba, Hieronymus in 1876, no. 399, ex Herb. Goettingen (P, Ber).

This variety intergrades freely with var. typica, as is evidenced by Clark 314 from Boise, Idaho (US); Eastwood 31 from Denver, Colo. (US); Bates from Long Pine, Nebr. (G). In these collections there is some pubescence on the fruits, but not enough to be representative of var. lachnocarpa. Material from Baja California tends to have smaller flowers and a more glabrous style than do other plants, but the tendencies do not seem to be definite enough to merit recognition. South American material matches very well that from North America, especially the small-flowered strain from Baja California. Varietal rank for this pubescent-fruited concept as opposed to the smooth-fruited sort which I am recognizing only as a form, seems justifiable because of the tendency to small flowers and the more distinctly southern range.

3. GAURA BIENNIS L., Sp. Pl., 347. 1753.

Biennial or winter annual, 3–30 dm. high, from a somewhat fusiform fleshy root; stem erect, pubescent to villous, simple below, openly much branched above; leaves soft-pubescent to glabrate, well distributed; rosette leaves oblanceolate, 1–3 dm. long, 2–4.5 cm. wide, subentire to irregularly sinuatedentate, narrowed into short winged petioles; cauline leaves numerous, oblong-lanceolate to lance-ovate, acute or acuminate at both ends, remotely denticulate, 3–10 cm. long, 1–2.5 cm. wide, narrowed gradually into very

short winged petioles, often with short axillary fascicles; floral bracts 1–4 mm. long, deciduous, ovate, acute; flowers open in evening, spicate, the slender spikes in open terminal panicles 1–5 dm. long; hypanthium slender, usually reddish, 5–7 mm. long, short-pubescent without, with dense curly pubescence within; sepals generally red, pubescent, 6–8 mm. long, narrow, reflexed in pairs at anthesis, without free tips in bud; petals white, aging pink, clawed, spatulate-elliptic, about 5 mm. long, the two upper ascending, the 2 lower horizontal; stamens subequal, the filaments flattened, glabrous, 5–7 mm. long, with very minute basal ovate, somewhat flattened scale, whitish; anthers white to pink, 2.5–3 mm. long, linear; style somewhat longer than stamens, reddish, with curly pubescence at very base; stigma-lobes ca. 1 mm. long; capsule pubescent, sessile, ovoid-fusiform, 4-angled, broadly 4-ribbed, acute at both ends, 4–7 mm. long, 1-few-seeded.

KEY TO VARIETIES

3a. Gaura biennis L. var. typica n.nom.

G. biennis Ll., Sp. P., 347. 1753; Curtis, Bot. Mag., pl. 389. 1797.

Stems, spreading-villous as well as short-pubescent; leaves glabrate, at least not canescent; hypanthium, buds, etc., with some short spreading gland-tipped hairs as well as some non-glandular ones.

Type locality, "Habitat in Virginia, Pennsylvania" according to Linnaeus. He refers to Plukenet (Alm., pl. 202, f. 7); this figure and the plant specimen in the Sloane Herbarium at British Museum from which the drawing seems to have been made, are apparently *Oenothera parviflora* L. In the Linnaean Herbarium are two specimens labeled *Gaura biennis*; both of which fit our concept.

The variety ranges from southern New England to Virginia and Missouri and Iowa. Representative material, MASSACHUSETTS: Cambridge, Morong in 1886 (NY). CONNECTICUT: New Haven, Eaton (G, P); Bristol, Bishop in 1897 (G, US). ONTARIO: Ft. Erie, Kolles in 1925 (NY). NEW YORK: Ithaca, Munz 767 (P), Coville in 1884 (US); Watkins, House 20109 (NY, US). NEW JERSEY: Princeton, Peters in 1885 (NY). DELAWARE: Hollyoak, Commons in 1896 (NY). PENN-SYLVANIA: Liverpool, Perry Co., Munz 13408 (P); Northampton Churchill in 1923 (G, P). MARYLAND: Kensington, Montgomery Co., Munz 13474 (P). WEST VIRGINIA: Mt. Crawford, Rockingham Co., Heller & Halbach 1200 (G, NY, US); White Sulphur Springs, Munz 13492 (P). VIRGINIA: Bedford Co., Curtiss in 1871 (G, NY). NORTH

CAROLINA: Cherokee, Swain Co., Munz 13522 (P); Biltmore, Biltmore Herbarium No. 458a (G, NY, US). TENNESSEE: La Follette, Campbell Co., Munz 13586 (P); Elizabethton, Wiegand & Manning 2162 (G). KENTUCKY: Wilmore, Jessamine Co., Anderson 585 (G). OHIO: Mansfield, Wilkinson 3425 (G, P); Toledo, Young in 1884 (G, NY). INDIANA: Near Ft. Wayne, Deam 21688 (NY). ILLINOIS: Peoria, McDonald in 1904 (G); Urbana, Pease 13041 (G). IOWA: Vinton, Davis 6 (US). MISSOURI: Gregory Landing, Clark Co., Drouet 1700 (P); Springfield, Standley 8348 (US).

- 3b. G. BIENNIS var. PITCHERI Pickering ex Torr. & Gray, Fl. No. Am. 1: 517. 1840.
- G. Pitcheri Pickering, 1. c, in synonymy; G. Pitcheri (Pickering) Small, Fl. S. E. U. S., 847, 1335. 1903.

Stems and leaves canescent, strigulose; hypanthium, buds, inflorescence strigulose or puberulent, not glandular.

Type locality, Red River. Ranging from Illinois to Nebraska and Texas. Representative material, ILLINOIS: Elk Grove, Cooke Co., Buhl F736 (P); St. Clair Co. Eggert in 1877 (G). IOWA: Dubuque, Mertz in 1877 (NY); Redfield, Dalles Co., Allen in 1867 (G). NEBRASKA: Lincoln, Webber in 1887 (US); Omaha, Cleburne (P). KANSAS: Riley Co., Norton 169 (G, NY, US); Lawrence, Snow (US). MISSOURI: St. Louis, Drummond in 1832 (NY); Monett, Barry Co., Munz 13556 (P); Van Buren, Carter Co., Munz 13589 (P). ARKANSAS: Little Rock, Hasse in 1885 (NY). OKLAHOMA: Tulsa, Stevens 2992 (G); Pawhuska, Osage Co., Stevens 1932 (G, NY, US). TEXAS: Decatur to Alvord, Wise Co., Ferris & Duncan 3324 (NY). Without definite locality, Red River Dr. Pitcher, type (NY).

Intergrades freely with var. typica, as evidenced by many specimens, for example: Carthage, Jasper Co., Mo., Eggleston 12072 (NY); Grinnell, Ia., Jones (P); Carroll, Ia., Pammel 23 (G, NY, US), all of which have the stem-pubescence of Pitcheri and bud-pubescence of typica. Examples with stem of typica and buds of Pritcheri are: Mira, Ill., Gleason 1980 (G); Peoria, McDonald in 1889 (G); and Utica, Ill., Clemens in 1909 (P).

4. GAURA NEOMEXICANA Wooton, Bull. Torrey Club 25: 307. 1898.

Biennial or perennial herb, from thick root; stems one to several from the base, erect, simple or few-branched above, 5–8 dm. high, greenish or reddish, pubescent; basal leaves 8–15 cm. long, the blades oblanceolate, subentire or sinuate-denticulate, pubescent, 4–7 cm. long, 1–2 cm. wide, narrowed into almost equally long winged petioles; cauline leaves mostly lanceolate, 5–10 cm.

long, 8–16 mm. wide, strigose, acute, subentire to minutely sinuate-denticulate, gradually narrowed into short winged petioles; upper ones reduced, subsessile; floral bracts lanceolate, pubescent, cuminate, 5–8 mm. long, caducous; inflorescence spicate, simple or few-branched, 1–4 dm. long in fruit; hypanthium slender, 8–12 mm. long pubescent, without, with a white matted curly pubescence within; sepals more or less red, reflexed separately in anthesis, linear-lanceolate, 9–11 mm. long; petals pink, short-clawed, spatulate to narrowly obovate, 8–10 mm. long; stamens subequal, filaments slightly enlarged upward, about as long as petals; with minute thickened basal scale; anthers linear, 3–4 mm. long; style somewhat longer than stamens, pubescent at very base; stigma-lobes surpassing the indusium 1–1.5 mm.; capsule 7–10 mm. long, fusiform, obtusely 4-angled and with a median nerve on each face, apparently 1-seeded.

G. neomexicana is undoubtedly very closely related to G. biennis and differs by being less branched, lower, more perennial, with larger fruits and flowers and a more western range. I am recognizing two varieties which differ from each other in much the same way as do those of G. biennis.

KEY TO VARIETIES

Stem spreading-villous as well as short-pubescent; inflorescence with some gland-tipped hairs as well as non-glandular ones. So. Colo. and New Mex........4a. G. neomexicana var. typica
Stem appressed- and short-pubescent only; inflorescence with non-glandular hairs only. No.
Colo.............4b. G. neomexicana var. coloradensis

4a. G. neomexicana Woot, var. typica n.nom.

G. neomexicana Woot., Bull. Torrey Club 25: 307. 1898.

Hair on stem of two kinds: long spreading and short appressed; inflorescence with gland-tipped and non-glandular hairs.

Type locality, White Mts., Lincoln Co., New Mex. Material seen, COLORADO: Piedra Paradra, Newberry in McComb Exped., 1859 (US); Piedra Creek, Wooton 2738 (US); Piedra, La Plata Co., Baker 491 (NY, P, US); Pagosa Springs, Archuleta Co., Baker 490 (G, NY, P, US). NEW MEXICO: Chama, Rio Arriba Co., Standley 6783 (NY, US); White Mts., Lincoln Co., Wooton 204, type coll., (NY, US); Cloudcroft, Otero Co., Wooton in 1899 (G, NY, P, US); Tularosa Creek, 3 mi. south of Mescalero Agency, Otero Co., Wolf 2768 (G, P); James Canyon, Sacramento Mts., Otero Co., Wooton in 1899 (US).

4b. G. neomexicana Woot. var. coloradensis (Rydb.) n.comb.

G. coloradensis Rydb., Bull. Torrey Club 31: 572. 1904.

Hair of stem short and appressed, of inflorescence not at all glandular.

Type locality, Ft. Collins, Colo. Material seen, COLORADO: Ft. Collins, Cowen, July 8, 1895, type coll. (G, NY), Cowen July 1, 1895 (US), meadows east of college, Crandall 1308 (NY).

5. GAURA MACROCARPA Rothrock, Proc. Amer. Acad. 6: 353. 1864-65.

Apparently perennial from rather woody caudex, with several ascending herbaceous stems, these simple or branched, 2-6 dm. tall, more or less scabrous-hirtellous throughout, cinereous; basal leaves oblanceolate to oblonglanceolate, 2-5 cm. long, sinuate-denticulate, more or less wavy, scabroushirtellous, hispid-ciliate, short-petioled; cauline leaves rapidly reduced up the stem, lower ones lanceolate, with 1 or 2 teeth on each side, 1-2 cm. long, 4-6 mm. wide; upper ones linear-oblong, subentire, 5-15 mm. long, 1-2 mm. wide, all hispid-ciliate, subcinereous; floral bracts lanceolate to subulate, rather persistent, 3-5 mm. long; spikes few-flowered, 5-12 cm. long, scarcely, peduncled, nodding at tip, scabrous-hirtellous; hypanthium strigulose without, slender, 8-10 mm. long, short-pubescent within; sepals lance-linear, 6-7 mm. long, strigulose, reflexed separately; petals white, turning red in age, rhombic-ovate, 5 mm. long and wide; stamens subequal; filaments strongly flattened, 3-4 mm. long; anthers 4-5 mm. long; style slightly surpassing stamens, short-puberulent at base; stigma-lobes ca. 1 mm. long; capsule can escent-puberulent, narrowly fusiform, straight or curved, slightly thicker in upper half, 10-15 mm. long, 1.5-2 mm. thick, terete, ribbed but not angled, sometimes somewhat narrowed at base into a short terete portion up to 3 mm. long.

Type locality, "valley of the Limpio," west Texas. Material seen, TEXAS: White Rose Pass, Davis Mts., Cory, May 4, 1936 (P); Ft. Davis, Jones 25880 (P); Davis Mts., Tracy & Earle 127 (NY, US); Ft. Davis, Palmer 34558 (NY, US), Young 1681 (US); valley of the Limpio, Wright 1079, type coll. printed "1879" by Rothrock (G, US); Limpio Mts., Havard 125 (G, US); Jeff Davis Co., Cory 2137 (P); San Felipe Springs, Val Verde Co., Cory 8998 (P); Boquillas, Brewster Co., Cory 2139 (P); 17 miles south of Alpine, Cory 9278(P). COAHUILA: San Lázaro, Castaños, Wynd & Mueller 145 (US) CHIHUAHUA: Chihuahua, Pringle 1497 in part (G), Palmer 195, in 1908 (NY, US).

As I understand this species, it is quite near to G. odorata, but differs in being scabrous, having shorter leaves and narrow fruit.

6. GAURA LINDHEIMERI Engelm. & Gray, Boston Journal Nat. Hist. 5: 217. 1845.

Perennial, simple or branched at base, the stems erect, 5–9 dm. tall, strigose and sometimes also short-hirsute, usually freely branched above; lower cauline leaves spathulate to oblong-oblanceolate, mostly sinuate-dentate, or -denticulate, acute to obtuse, 3–9 cm. long, 7–15 mm. wide, subsessile or with short winged petiole, strigose; upper ones reduced, subentire; floral bracts ovate to lanceolate, 5–10 mm. long, thin, caducous, more or less villous; spikes simple, or usually branched and in open panicles 2–6 dm. long, on

peduncles 5 or more cm. long; axes glabrous or usually more or less pilose and also glandular-pubescent, nodding at tips; hypanthium usually reddish, slender, 5–8 mm. long, externally with scattered gland-tipped hairs and usually some longer non-glandular ones, internally with white interwoven hairs; sepals more or less reddish, pilose and glandular-pubescent, 12–15 mm. long, lance-linear, separately reflexed in anthesis; petals white, changing to rose, spatulate-rhomboid, short-clawed, 12–20 mm. long; stamens subequal, the filaments slightly flattened upward, 10–15 mm. long; anthers red, ca. 4 mm. long; style slightly exceeding stamens, pubescent at base; stigma-lobes ca. 0.5 mm. long; fruit elliptic-oblong, about equally narrowed at both ends, 7–9 mm. long, sharply 4-angled, each face 2 mm. wide, 1-ribbed and somewhat furrowed apically, subglabrous to scattered-pilose.

Type locality, apparently Houston, Texas. Growing in prairie sod, southeastern Texas and adjacent Louisiana and Mexico. Representative material, TEXAS: Houston, Rose 18127 (NY, US), Palmer 12792 (G, NY, US), Munz 13339 (P); Sheldon, Reverchon 3842 (G, P, US); 3 miles east of Liberty, Liberty Co., Munz 13342 (P); 2.6 mi. east of Camp Jackson, Hardin Co., Cory 19765 (P); Amelia, Jefferson Co., Cory 11091 (P); Beaumont, Reverchon 3841 (G, P, US). LOUISIANA: Jennings, Jefferson Davis Parish, Munz 13340 (P), Palmer 7612 (NY, US); Mermentau, Acadia Parish, Degner 5120 (NY); Centreville, St. Mary Parish, Munz 1588 (P). MISSISSIPPI: Grant Batture Id., Howell 746 (US). COAHUILA: Saltillo, Nil in 1910 (G, NY). NUEVO LEON: Monterrey, Arsène in 1911 (NY).

This species is characterized by its large flowers, pilose sepals and elliptic fruit. It is rather variable in pubescence, such collections as *Reverchon 3841*, *Palmer 7612*, and *Munz 13340* being partly or quite hirsute.

7. GAURA ANGUSTIFOLIA Michx., Fl. Bor. Am. 1: 226. 1803.

Winter annual, or biennial?, 6–18 dm. tall, mostly erect, simple below, with open divaricate slender branches above; rosette-leaves narrowly oblanceolate, 5–18 cm. long, 7–15 mm. wide, irregularly sinuate-dentate to almost runcinate, acute, narrowed gradually into a winged petiole which varies from 1–7 cm. in length; main cauline leaves narrowly oblanceolate to narrowly lanceolate, subsessile or short-petioled, 3–6 cm. long, 5–8 mm. wide, subentire to sinuate-denticulate, acute; upper cauline leaves gradually reduced, lance-linear, 1–3 cm. long, 1–3 mm. wide, subentire; floral bracts lance-linear, 2–4 mm. long, caducous; spikes 1–3 dm. long, very slender, simple or openly branched; hypanthium slender, more or less reddish, 3–5 mm. long, pubescent within with rather long curly hairs; sepals somewhat reddish, 5–7 mm. long, separately reflexed or more or less adherent in anthesis; petals white or pink, spatulate to spatulate-oblong, 4–6 mm. long; stamens slightly unequal, 4–5

mm. long; filaments somewhat flattened, glabrous, each with very minute fleshy basal scale; anthers oblong, ca. 1 mm. long, white to pinkish; style slightly exceeding stamens, pubescent in lower part; stigma-lobes ca. 0.5 mm. long; capsule elliptic to narrowly ovoid, rather sharply 3-4-angled, 5-10 mm. long, narrowed into pedicel-like base 0.5-1.0 mm. long, apparently 1-2-seeded.

Exceedingly variable as to pubescence and length of capsule, of which the wings may be 3 or 4, both forms often occurring on the same plant. The following varieties are not very clear, but having some definiteness in range as well as pubescence seem worth recognition.

KEY TO VARIETIES OF G. ANGUSTIFOLIA

Capsules pubescent; sepals pubescent. No. Car. to Fla. and Ala. Pubescence of sepals and capsules loose and spreading. Pubescence of sepals and capsules fine and closely appressed. Fla.

Capsules and sepals glabrous. Stem, leaves and axes of inflorescence pubescent. So. Fla.

Stem, leaves and inflorescence-axes glabrous. Punta Rassa, Fla.

7a. var. typica 7b. var. strigosa

7c. var. simulans 7d. var. Eatonii

7a. G. angustifolia Michx. var. typica n.nom.

G. angustifolia Michx., Fl. Bor. Am. 1: 226. 1803. G. undulata Desf., Tableau de l'Ecole de Bot., ed. 2, 196. 1815, nomen. G. fruticosa Jacq., Coll. 1: 142, pl. 181. 1786 and Ic. Rar. 3: pl. 457. 1786-1793; not G. fruticosa Loefl., Iter Hispan., 248. 1758. G. longiflora Spach, Nouv. Annal. Mus. Paris 4: 380. 1835.

Stem strigose; leaves somewhat strigose, especially on the veins of under surface and on margins; inflorescence pubescent throughout short puberulent only (or with some longer additional hairs); capsule likewise pubescent, even short-villous.

Type locality, "in Carolina inferiore." Ranging from No. Car. to Fla. and Ala. Representative material, WITHOUT LOCALITY: G. fruticosa, en h.v. paris 1787, Herb. Jussieu (Paris); Hort. Paris 1790 (BM, photo at G & P); "G. angustifolia," Herb. Michx. (Paris). NORTH CAROLINA: Vandemer, Pamlico Co., L. F. & F. R. Randolph 856 (G); Wilmington, Coville 149 (US). SOUTH CAROLINA: Beaufort, Lewis 192 (NY); Pine Island, Harris C 19734 (US); 14 mi. east of Waterboro, Wiegand & Manning 2160 (G). GEORGIA: Wilmington Island, Hopkins 24 (NY). ALABAMA: Rosemary, Hale Co., Harper 3253 (NY, US); Cedarpoint, Mohr in 1893 (US); Mobile, Mohr in 1895 (US). FLORIDA: near Jacksonville, Drummond in 1833, apparently type coll. of longiflora (G, K, photo at P), Curtiss 895 (G. NY, US); Lake City, Wiegard & Manning 2161 (G); Ft. Pierce, Santa Lucie Co., Burgess 735 (NY); Cape Canaveral, Broward Co., Burgess 654 (NY).

7b. G. angustifolia Michx. var. strigosa n.var.

Stem, leaves and inflorescence (hypanthium sepals, ovaries) finely strigulose.

Type, Eustis, Lake Co., Fla., G. V. Nash 1464, July 16-31, 1894 (NY); isotypes at Gray and U. S. National Herbarium. Found in northcentral Florida. Material seen, FLORIDA: St. Charles, Rugel in 1843 (NY); Eustis, Lake Co., Hitchcock in 1894 (P); St. Petersburg, Beckwith 728 (US); So. Jacksonville, Lighthipe 277 (NY), 276 (NY); Appalachicola, Gulf Co., Chapman (NY, US); Duval Co., Fredholm 234 (P), 5240 (US); Alligator Harbor, Tracy 7599 (US); Tallahassee, Berg (NY); Tampa, Garber in 1876 (US); St. Vincent Island, McAtee 1750 (US).

7c. G. angustifolia Michx. var. simulans (Small) n.comb.

G. simulans Small, Bull. N. Y. Bot. Garden 3: 432. 1905.

Stems pubescent; leaves pubescent; inflorescence axes pubescent; hypanthium, sepals and ovaries glabrous.

Type locality, between Cocoanut Grove and Cutler, Dade Co., Fla. Range in southern Florida. Material seen, FLORIDA: Myers, Lee Co., Hitchcock 123 (G, NY, US); 8 miles southeast of Ft. Myers, Standley 474 (G, P); Buckingham, Lee Co., Moldenke 1008 (NY, US); Miami, Garber in 1877 (G, US in part), Small & Small 4822 (NY), Small, Carter & Small 3255 (NY); Silver Palm School, Dade Co., Small 2195 (NY); between Cocoanut Grove & Cutler, Small & Wilson 591 (NY), Small & Carter 766, type coll. (G, NY); Miami Beach, Moldenke 584 (NY, US); between Miami & Kendall Station, Small & Carter 2606 (NY); Virginia Key, Britton 102 (NY); Sykes Hammock, Dade Co., Small et al. 5765 (NY).

7d. G. angustifolia Michx. var. Eatonii (Small) n.comb.

G. Eatonii Small, Fl. S.E. U.S., ed. 2, 1353, 1375. 1913. Stems, leaves, inflorescence and fruit glabrous.

Type locality, Punta Rassa, Lee Co., Florida. Material seen, Punta Rassa, Eaton 1107 (G), 1289, type (NY), Standley 261 (G, NY, US), 12673 (US) Shell Island, Tracy 7598 (G, NY, US); Naples, Degner 4943 (NY); Salvista, Moldenke 1032a (NY); Ft. Myers, Moldenke 917 (NY), 789 (NY); Captiva, Lee Co., Orron in 1915 (US); Clearwater Beach, Beckwith in 1921 (US).

8. GAURA FILIFORMIS Small, Bull. Torrey Club 25: 617. 1898.

Biennial, erect, 6–25 dm. tall, more or less canescent-strigose throughout, simple at base, freely and divaricately branched above, the ultimate branchlets almost filiform; rosette-leaves not seen; lower cauline leaves lanceolate, 4–10 cm. long, 8–15 mm. wide, subentire to sinuate-dentate, acute, narrowed gradually into very short winged petioles; upper leaves reduced, lance-linear, acuminate, subsessile, quite entire, 1–3 cm. long, 2–4 mm. wide; floral bracts

almost linear, 4–6 mm. long, caducous; inflorescence of slender spikes in an open panicle, 1–3 dm. long, finely canescent-strigose throughout; hypanthium slender, 4–6 mm. long, strigulose without, with heavy white pubescence within; sepals narrow, 8–10 mm. long, usually more or less adherent in anthesis; petals "pink-purple," about 7 mm. long, clawed, spatulate; stamens somewhat unequal, with flattened filaments 6–7 mm. long; anthers linear, 2.5–3 mm. long, purplish; style pubescent at base, exceeding the stamens by 2–4 mm.; stigma-lobes 0.4–0.8 mm. long; capsule quite sessile, canescent, 3–6 mm. long, somewhat fusiform, 4-angled, each side with a median rib; seeds 1–2.

KEY TO VARIETIES

8a. Gaura filiformis Small var. typica n.nom.

G. filiformis Small, Bull. Torrey Club 25: 617. 1898. G. exaltata Engelm. & Gray, Boston Journ. Nat. Hist. 5: 44. 1845, nomen nudum.

Hypanthium and sepals with appressed non-glandular hairs.

Type locality, Texarkana, Miller Co., Ark. Range, from Miss. and La. to Ark. and eastern Texas. Representative material, MISSISSIPPI: Biloxi, Tracy 5071, in part (G); Ocean Springs, Pollard 1021 (G, NY, US); Agricultural College, Oktibbcha Co., Pollard 1320 (G, NY, US); Shelton, Rhoades in 1931 (G). LOUISIANA: Opelousas, without collector (US); Alexandria, Hale (NY); Felciana & Opelousas, Carpenter (NY). ARKAN-SAS: Texarkana, A. A. & E. G. Heller 4138, type coll. (G, NY. US); 6 mi. north of Hot Springs, Scully 377 (P); Ft. Smith, Bigelow in 1853-4 (US). TEXAS: Richmond, Ft. Bend Co., Palmer 6655 (P, US); Houston, Lindheimer 239 number referred to under exaltata (G, US); Dallas, Reverchon 39 (G); Morgan's Point, Harris Co., Cory 8140 (P); 7 miles west of Dickinson, Galveston Co., Cory 11398 (P).

This variety is often easily confused with *G. biennis* var. *Pitcheri*, but in a mature enough condition, the more sharply angled fruits of *filiformis* are distinctive.

8b. G. filiformis Small var. Kearneyi n.var.

Hypanthium and sepals with some very short spreading hairs, some of which may be gland-tipped. (Hipantium et sepala cum capillis curtis divaricatisque, cum alteris glandulosis.)

Type, from along railroad track, Starkville, Miss., Sept. 28, 1896 T. H. Kearney Jr., (NY). Other material seen, ALABAMA: Cocoa, Choctaw Co., Schuchert in 1896 (NY, US). MISSISSIPPI: Biloxi, Tracy 5071, (NY in part, US), Lloyd & Tracy 224 (NY); Ocean Springs, Seymour 84 (G).

TEXAS: seven miles west of Lufkin, Angelina Co., Cory 10633 (P); Roston, Lamar Co., Cothran 17479 (P); Newton, Newton Co., Cory 10906 (P). 8c. G. FILIFORMIS Small var. MUNZII Cory.

Hairs of hypanthium and sepals non-glandular, spreading, ca. 1 mm. long. Type locality, $6\frac{1}{2}$ miles north of High Island, Chambers Co., Texas. Specimens seen, $6\frac{1}{2}$ miles no. of High Island, Texas, Cory 20179 (P), 20180 (P); $6\frac{1}{2}$ miles west of Alvin, Brazoria Co., Cory 11399 (P).

9. GAURA SUFFULTA Englm. ex Gray, Boston Journ. Nat. Hist. 6: 190, 1850. Apparently winter annual or biennial, 2-8 dm. tall, usually few-branched at base or above, and ascending, sometimes simple and erect; stems spreadingvillous in leafy portion; basal leaves in a rosette, oblanceolate, 5-18 cm. long 1-2.5 cm. wide, runcinate-pinnatifid, usually subglabrous except for the villous margins, veins and petioles; petioles winged, making up $\frac{1}{4}$ length of whole leaf; cauline leaves rather crowded, oblanceolate to lanceolate, 4-10 cm. long. 1-2 cm. wide, acute, sinuate to subentire, short-villous on veins and margins. with winged petioles 4-15 mm. long; uppermost lance-linear, 1-3 cm. long; floral bracts glabrous, oblong-ovate, 6-10 mm. long, acuminate, reddishveined, caducous; spikes glabrous, simple, becoming 1-3.5 dm. long, and on a naked, more or less villous peduncle 5-15 cm. long; hypanthium slender, somewhat reddish, 5-12 mm. long, with dense white pubescence within; sepals oblong-linear, with some red veining, 8-10 mm. long, reflexed singly or in pairs at anthesis; petals white, aging pink, oblong to oblong-spatulate, 9-10 mm. long; stamens subequal filaments slightly flattened, 5-6 mm. long, with basal scale; anthers linear-oblong, 4-5 mm. long, somewhat reddish; style pubescent at base, somewhat exceeding stamens; stigma-lobes whitish, ca. 0.6 mm. long; capsule sessile, ovoid, 4-7 mm. long, glabrous, wing-angled above, obtusely angled below, with median rib on each face; seeds 1-few.

KEY TO VARIETIES

9a. Gaura suffulta Engelm. var. typica n.nom.

G. suffulta Engelm. ex Gray, Boston Journ. Nat. Hist. 6: 190. 1850.

Hypanthium and sepals mostly glabrous except for some hair along the edges of the latter; hypanthium 5-7 mm. long.

Type locality, New Braunfels, Texas. Ranging widely in Texas, rare in Okla. and Tamaulipas. Representative material, OKLAHOMA: Arbuckle Mts., Murray Co., Goodman 2448 (P). TEXAS: Austin, Hall 212 (G, NY, P, US); New Braunfels, Lindheimer 611, type coll. (G, NY, US); Dallas, Curtiss dist. 896 (G, NY, US); San Antonio, Clemens 697 (NY, P); Midland, Midland Co., Cory 8743 (P); Ozona, Crockett Co., Jones 25878 (P); Five-mile Creek, Upton Co., Cory 583 (P); Ranch Experiment Sta-

tion, Edwards Co., Cory 15268 (P). TAMAULIPAS: Matomoros, Berlandier 2313=883 (K, photo at P). As an escape at Philadelphia, Pa., Martindale in 1882 (US).

9b. G. suffulta Engelm. var. terrellensis n.var.

Hypanthium and sepals glandular-pubescent; hypanthium 10-12 mm. long. (Hipantium et sepala glanduloso-puberulenta; hipantio 10-12 mm.longo.)

Type, Sanderson, Terrell Co., Texas, Mayl, 1934, Cory 8469, Pomona College Herbarium No. 200873. Known from a single collection.

10. Gaura gracilis Wooton & Standley, Contr. U. S. Nat. Herb. 16: 153. 1913.

Apparently biennial to short-lived perennial, branched at base, bushy, the stems slender, often reddish, hirsute or villous, simple or usually branched, ascending, 4-9 dm. high; basal leaves oblanceolate, sinuate-dentate, 4-10 cm. long, villous especially on margins and veins, with short winged petioles; cauline leaves rather numerous, linear or linear-oblong, entire to repandtoothed, more or less wavy, glabrous to stiff-pubescent, mostly 1-4 cm. long, 1-3 mm. wide, subsessile to very short-petioled, acute to obtuse; bracts of inflorescence ovate, acute to acuminate, ciliolate, 1-2 mm. long; spikes slender, simple or few-branched, relatively few-flowered, becoming 5-20 cm. long in fruit, on peduncles 5-15 cm. long; hypanthium reddish, slender, 5-7 mm. long, pubescent within; sepals reddish, linear, 4-5 mm. long, separate in anthesis; petals white to reddish, oblanceolate, 5-6 mm. long; stamens subequal, the filaments somewhat flattened, 4-5 mm. long; anthers reddish, ca. 2 mm. long; style exceeding stamens, pubescent at base, the stigma-lobes ca. 0.2 mm. long; capsule quite sessile or short-stipitate, ovoid-pyramidal, sharply 4-angled, mostly 4-6 (9) mm. long, and 2-2.5 mm. wide, glabrous, somewhat wrinkled transversely.

This species has been included in G. suffulata, but differs in its narrower cauline leaves, smaller flowers, and more western range at a higher altitude. It intergrades with G. Nealleyi to some extent through the forma glandulosa.

KEY TO VARIETIES

10a. Gaura gracilis Woot. and Standl. var. typica n.var.

G. gracilis Woot. & Standl., Contrib. U. S. Nat. Herb. 16: 153. 1913. G. podocarpa Woot. & Standl., l.c., 154. G. strigillosa Woot. & Standl., l.c. G. brassicacea Woot. & Standl., l.c., 152.

Hypanthium and calyx minutely strigillose to glabrous.

Type locality, Forest Nursery, Ft. Bayard, New Mexico. Range from Ariz. to western Texas and Durango. Representative material, ARIZONA: $\frac{1}{2}$ mile west of Prescott, Yavapai Co., Wolf 2340 (G, P); Prescott, Peebles, Harrison & Kearney 8843 (G, P); Devils Canyon, Pinal Mts., Kearney

Peebles & Harrison 3194 (Sac, US); Pine Canyon, Chiricahua Mts., Blumer 1601 (G, NY, US); Santa Rita Mts., Jones in 1903 (P); Garden Canyon, Huachuca Mts., Harrison & Kearney 5798 (Sacaton, US). NEW MEXICO: Ft. Bayard Watershed, Blumer 44, type coll. gracilis (G, NY, US); Ruidoso Creek, White Mts., Lincoln Co., Wooton in 1895, type coll. strigillosa (US); Silver City, Grant Co., Metcalfe 166, type coll. podocarpa (G, NY, P, US); Socorro, Vasey in 1881, type brassicacea (US); Mimbres River, Black Range, Grant Co., Metcalfe 1033 (G, NY, P, US); Pinos Altos Mts., Greene in 1880 (G, NY, P). TEXAS: Rankin, Upton Co., Cory 5136 (P); Converse, Bexar Co., Wolff 980 (US). CHIHUAHUA: Chihuahua, Palmer 204, in 1908 (G, NY, US); near Pilares, Hartman 796 (G, NY, US); Soldier Canyon, Sierra Madre, Jones in 1903 (P). DURANGO: La Providencia, Nelson 4982 (US); Otinapa, Palmer 552 (US); Durango, Nelson 4619 (G, US).

The intergradation from a strigillose to a glabrous condition is so gradual and complete, as is that from a non-stipitate to a stipitate condition that I am unable to maintain the entities described by Wooton and Standley for recognition of these, such as podocarpa, strigillosa. I have not been quite so certain as to the status of G. brassicacea as of the others, and for that reason take up the name gracilis for this concept although brassicacea has page priority. I do agree with Wooton and Standley in maintaining this whole concept as a species distinct from suffulta. Their glandulosa seems to be a little more definite thing than the others, and yet, since it has no definite range or other characters, but is found growing with the typical form of the species, I am recognizing it as

10b. Gaura gracilis Woot. & Standl. forma glandulosa (Woot. & Standl.) n. comb.

G. glandulosa Woot. & Standl., Contrib. U. S. Nat. Herb. 16: 153. 1913. Hypanthium and calyx with short gland-tipped hairs.

Type locality, Reserve, Catron Co., New Mexico. Ranging with var. typica, Representative material, ARIZONA: 3 miles east of Flagstaff, Munz 13002 (P); Willow Spring, Rothrock 233 (G, US); Santa Catalina Mts., Livingston & Thornber in 1906 (NY); Miller's Canyon, Huachuca Mts., Goodding 250 (G, NY); Matzatzal Mts., Collom (NY, US). NEW MEXICO: White Mts., Lincoln Co., Wooton 339 (NY, US); Reserve, Wooton in 1906, type coll. (US). CHIHUAHUA: Colonia Garcia, Sierra Madre, Townsend & Barber 124 (G, NY, P, US); Sierra Madre, Nelson 6110 (US).

There is considerable variation in fruit length (from 5-12 mm.), but I am unable to maintain any segregation by use of it.

(to be concluded)

INDEX TO AMERICAN BOTANICAL LITERATURE 1934-1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the

word America being used in the broadest sense.

This index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the Index may be addressed to the Treasurer of the Torrey Club.

Airy-Shaw, H. K. Symplococarpon Hintoni (Bullock) Airy-Shaw. Hooker's Icon. Plant 34: pl. 3342. S 1937. A new genus from Mexico.

Albaum, H. G. & Kaiser, S. The titration curves of 3-indole acetic, 3-indole propionic, and 3-indole butyric acids. Am.

Jour. Bot. 24: 420-422. f. 1-3. Jl 1937.

Arena, A. Influencia de la concentracion de los iones hidrogeno del suelo en el crecimiento de la alfalfa. Revista Argentina Agron. 1: 116-132. pl. 1+f. 1, 2. Au 1934.

Arnon, D. I. Ammonium and nitrate nitrogen nutrition of barley at different seasons in relation to hydrogen-ion concentration, manganese, copper and oxygen supply. Soil Science 44: 91-113. pl. 1-4+f. 1-8. Au 1937.

Avery, G. S., Burkholder, P. R. & Creighton, H. B. Polarized growth and cell studies in the first internode and coleoptile of Avena in relation to light and darkness. Bot. Gaz. 99:

125-143. f. 1-8. 27 S 1937.

Azevedo, N. Observações sobre uma doença de virus em tomateiro. Rodriguesia 2: 209-212. 1936.

Babcock, E. B. & Stebbins, G. L. The genus Youngia. Carnegie Inst. Washington Publ. 484: 1-106. pl. 1-5+f. 1-31. 19 Au 1937.

Babcock, E. B., Stebbins, G. L. & Jenkins, J. A. Chromosomes and phylogeny in some genera of the Crepidinae. Cytologia Fujii 1: 188-210. f. 1-6. Je 1937.

Barkley, F. A. Studies in the Anacardiaceae. II. Ann. Missouri Bot. Gard. 24: 499-500. 27 S 1937.

Barnett, H. L. Studies in the sexuality of the Heterobasidiae. Mycologia 29: 626-649. f. 1-3. S-O 1937.

Bausor, S. C. Fasciation and its relation to problems of growth II. Changes from the fasciated to the normal state, with a discussion on the nature of the shoot. Bull. Torrey Club **64:** 445–475. f. 1–58. O 1937.

- Beadle, G. W. Chromosome aberration and gene mutation in sticky chromosome plants of *Zea mays*. Cytologia Fujii 1:43-56. Je 1937.
- Beard, E. C. Some chromosome complements in the Cactaceae and a study of meiosis in *Echinocereus papillosus*. Bot. Gaz. 99: 1-21. pl. 1, 2+f. 1-65. 27 S 1937.
- Beatty, A. V. A statistical study of flower doubling in Eschscholtzia californica Cham. Genetica 19: 447-464. 1937.
- Bell, H. P. The protective layers of the apple. Canadian Jour. Res. 15: 391-402. f. 1-10. Au 1937.
- Benatar, R. Sobre uma nova mancha em epicarpo de "Citrus sinensis" Osbeck causado pelo Phoma Puttemansii n. sp. Rodriguesia 2: 306-313. f. 1-6. Mr 1936.
- Blake, M. A., Nightingale, G. T. & Davidson, O. W. Nutrition of apple trees. New Jersey Agr. Exp. Sta. Bull. 626: 1-41. f. 1-16. Je 1937.
- Blossfeld, H. Beobachtungen über die Kakteenflora an den Quellen des Amazonas. Kakteenkunde 8: 113-115. illust. Au 1937.
- Bonner, J. & Addicott, F. Cultivation in vitro of excised pea roots. Bot. Gaz. 99: 144-170. f. 1-3. 27 S 1937.
- Boswell, V. R. Improvement and genetics of tomatoes, peppers, and eggplant. U. S. Dept. Agr. Yearbook Agr. Res. 1937: 176–206. f. 1–3. 1937.
- Brandwein, P. F. Experiments on latent infection of resistant varieties by the loose and covered smut of oats. Bull. Torrey Club 64: 433-444. O 1937.
- Bravo, H. H. Observaciones floresticas y geobotanicas en el valle del Mezquital, Hidalgo. An. Inst. Biol. Mexico 8: 3-82. f. 1-24. 1937.
- Brooks, A. B. Castanea dentata. Castanea 2: 61-67. illust. My 1937.
- Brown, A. B. & Cormack R. G. H. Stimulation of cambial activity, locally in the region of application and at a distance in relation to a wound by means of heteroauxin. Canadian Jour. Res. 15°: 433-441. pl. 1. S 1937.
- Brown, C. A. Some wild flowers of Louisiana. Louisiana Conserv. Rev. 4: 18-24. illust. Ap 1935; 4: 22-29. illust. Jl 1935; 4: 32-37. illust. O 1935; 5: 12-23. f. 1-19. Ja 1936; 5: 34-39. f. 1-6. O 1936.
- Brown, H. J. A new species of Vaucheria from northern Michigan. Trans. Am. Microscop. Soc. 56: 283-284. f. 1. Jl 1937.

Brown, R. W. Additions to some fossil floras of the western United States. U. S. Dept. Int. Prof. Paper 186-J: 163-206. pl. 45-63. 1937.

Bukasov, S. M. & Lechnovitz, V. Importancia en la fitotecnia de las papas indigenas de la America del Sur. Revista Argentina Agron. 2: 173-183. f. 1. D 1935.

Bullock, A. A. Chaptalia Hintoni Bullock. Hooker's Icon. Plant. 34: pl. 3346. S 1937.

A new species from Mexico.

Bullock, A. A. Chaptalia nutans (Linn.) Hemsl. Hooker's Icon. Plant. 34: pl. 3345. S 1937. A plant from Mexico.

Bullock, A. A. Perezia Pringlei Robine. et Greenm. Hooker's Icon. Plant. 34: 3347. S 1937.

A plant from Mexico.

Bullock, A. A. Senecio bombycopholis Bullock. Hooker's Icon. Plant. 34: 3343. S 1937.

A new species from Mexico.

Bullock, A. A. Senecio moreliae Hemsl. Hooker's Icon. Plant. 34: pl. 3344. S 1937.

A plant from Mexico.

Bullock, A. A. Trixis decurrens DC. Hooker's Icon. Plant. 34: pl. 3348. S 1937.

A plant from Mexico.

Burkart, A. Frecuencia de la fecundacion druzada en la Alfalfa, segun experiencias con plantas recesivas de flor blanca. Revista Argentina Agron. 4:83-100. Je 1937.

Burkart, A. Las especies Argentinas y Uruguayas del genera Caesalpinia. Revista Argentina Agron. 3: 67-112. pl. 1-10 +f. 1-6. Au 1936.

Burret, M. Beiträge zur Kenntnis der Tiliaceae. IV. Notizbl. Bot. Gart. Berlin 12: 602-605. 6 D 1935.

Burret, M. Palmae neogeae XI. Notizbl. Bot. Gart. Berlin 13: 478-481. 30 Je 1937.

Burret, M. Plantae Duqueanae. Notizbl. Bot. Gart. Berlin 13: 489-500. 30 Je 1937.

Calvino, M. La patata dolce. Staz. Sper. Floricolt. Sanremo 15: 1-16. f. 1-13. 1936.

Camp, W. H. Notes on the physiology and morphology of Amorphophallus titanum. Jour. N. Y. Bot. Gard. 38: 190-197. f. 3-5. Au 1937.

Campbell, W. A. The cultural characteristics of Fomes connatus. Mycologia 29: 567-571. f. 1, 2. S-O 1937.

Castle, H. A revision of the genus Radula. Ann. Bryologici 9: 13-56. f. 1-15. Jl 1937.

- Chadwick, L. C. Chemicals hasten root growth. American Nurseryman 65¹⁰: 4-5. 15 My 1937; 65¹¹: 9-11. 1 Je 1937.
- Chamberlain, C. J. Alternation of generation. Cytologia Fujii 1: 576-582. Je 1937.
 - **Chester, K. S.** A critique of plant serology. III. Phytoserology in medicine and general biology. Bibliography. Quarterly Rev. Biol. 12: 294–321. S 1937.
 - Chester, K. S. Anaphylaxis tests for differentiating the proteins of normal Solanaceae. Am. Jour. Bot. 24: 451-454. f. 1-3. Jl 1937.
 - Chester, K. S. Serological studies of plant viruses. Phytopathology 27: 903-912. S 1937.
 - Clark, W. G. Ascorbic acid in the Avena coleoptile. Bot. Gaz. 99: 116-124. 27 S 1937.
 - Clokey, I. W. A new *Penstemon* from the Charleston Mountains, Nevada. Madroño 4: 128-130. 4 O 1937.
 - Coffing, C. A quantitative study of the phytoplankton of the White River Canal, Indianapolis, Indiana. Butler Univ. Bot. Stud. 4: 13-31. S 1937.
 - Conant, N. F. The occurrence of a human pathogenic fungus as a saprophyte in nature. Mycologia 29: 597-598. S-O 1937.
 - Copeland, H. F. On the pollen of the Mimosoideae and the identity of the supposed alga *Phytomorula*. Madroño 4: 120-125. pl. 20. 4 O 1937.
 - Cormack, M. W. Cylindrocarpon Ehrenbergi Wr., and other species, as root parasites of alfalfa and sweet clover in Alberta. Canadian Jour. Res. 15°: 403–424. pl. 1+f. 1–3. S 1937.
 - Couch, J. N. Notes on the genus *Micromyces*. Mycologia 29: 592-596. f. 1-14. S-O 1937.
 - Craig, R. T. Mammillaria viridiflora. Jour. Cactus & Succ. Soc. Am. 9: 29-30. illust. Au 1937.
 - Crane, H. L., Reed, C. A. & Wood, M. N. Nut breeding. U. S. Dep. Agr. Yearbook Agr. 1937: 827–889. f. 1–12. 1937.
 - Croizat, L. Chinese and Siberian elms. American Nurseryman 65¹¹: 4-5. illust. 1 Je 1937.
 - Darrow, G. M. Blackberry and raspberry improvement. U. S. Dep. Agr. Yearbook Agr. 1937: 496-533. f. 1-14. 1937.
 - Darrow, G. M. Improvement of currants and gooseberries. U. S. Dep. Agr. Yearbook Agr. 1937: 534-544. f. 1, 2. 1937.
 - **Darrow, G. M.** Strawberry improvement. U. S. Dep. Agr. Yearbook Agr. 1937: 445-495. f. 1-18. 1937.
 - Davies, P. A. Leaf arrangements in Ailanthus altissima. Am. Jour. Bot. 24: 401-407. f. 1-7. Jl 1937.

Davy, J. B. On the primary groups of dicotyledons. Ann. Bot. II. 1: 429-437. Jl 1937.

Dayton, W. A. Notes on harmel, or "Syrian rue." Jour. Washington Acad. Sci. 27: 349-351. 15 Au 1937.

DeLamater, E. D. Eidamella spinosa (Matruchot and Dassonville) refound. Mycologia **29:** 572–582. f. 1–27. S–O 1937.

Denny, F. E. A retrial of the ethylene chlorhydrin method for hastening the germination of freshly harvested *Gladiolus* corms. Contr. Boyce Thompson Inst. 8: 473-478. Ap-Je 1937.

Diels, L. Ein neuer Styrax aus Mexiko. Notizbl. Bot. Gart. Berlin 13: 508. 30 Je 1937.

Dittmer, H. J. A quantitative study of the roots and root hairs of a winter rye plant (Secale cereale). Am. Jour. Bot. 24: 417-420. Jl 1937.

Dixon, H. N. On a collection of mosses from Laos. Ann. Bryologici 9: 60-72. Jl 1937.

Dixon, H. N. & Fleischer, M. Bryophyta nova (26-29). Ann. Bryologici 9: 139-141. Jl 1937.

Dluhosch, H. Die Blüten der Coniferen. Bibliotheca Botanica 1143: 1-20. pl. 1-6. 1937.

Donat, A. Problemas fitogeograficos relativos a la region Magallanica. Revista Argentina Agron. 2: 86-95. f. 1, 2. Au 1936.

Drathen, T. La Virescencia como fenomeno frecuente en algunas especies vegetales. Rev. Chilena Hist. Nat. 39:153-159. f. 24-26. 1935.

Ducke, A. The Muirapirangas of Brazilian Amazonia. Tropical Woods 51: 15-18. 1 S 1937.

Eastwood, A. New species of *Dodecatheon*. Leafl. West. Bot. 2: 36-38. 26 Au 1937.

Eastwood, A. Zygadenus fontanus, a new species from Mt. Tamalpais. Leafl. West. Bot. 2:41-42. 26 Au 1937.

Epling, C. The Labiatae of northern South America: Colombia, Ecuador and Venezuela. Repert. Spec. Nov. Beih. 95: 5-144. 5 S 1937.

Everett, T. H. Plant portraits. Gard. Chron. Am. 41: 249-250. illust. S 1937.

Everett, T. H. Summer flowers in the southern Appalachians. Gard. Chron. 102: 232-234. f. 98-101. 25 S 1937.

Everett, T. H. The cultivation and development of Amorpho-phallus titanum. Jour. N. Y. Bot. Gard. 38:181-185. f. 1, 2. Au 1937.

Faegri, K. Some recent publications on phytogeography in Scandinavia. Bot. Rev. 3: 425-456. S 1937.

- Fawcett, W. & Rendle, A. B. Flora of Jamaica 1: i-xviii+1-150. pl. 1-32. 1910; 5: i-xxviii+1-453. f. 1-156. 24 Jl 1926; 7: i-ix+1-303. 25 Jl 1936.
 Vol. 7 by S. Le Marchant Moore & A. B. Rendle.
- Fernald, M. L. Nomenclatural transfers and new varieties and forms. Rhodora 39: 309-320. pl. 470-473. Au 1937.
- Fernald, M. L. & Griscom, L. Notes on *Diodia*. Rhodora 39: 306-308. pl. 469. Au 1937.
- Flory, W. S. Chromosome numbers in the Polemoniaceae. Cytologia Fujii 1: 171-180. f. 1-19. Je 1937.
- Fosberg, F. R. The genus Gouldia (Rubiaceae). Bernice P. Bishop Mus. Bull. 147: 1-82. pl. 1-3+f. 1. 1937.
- Foster, H. H. Studies of the pathogenicity of *Physalospora obtusa*. Phytopathology 27: 803-823. f. 1-6. Au 1937.
- Fox, L. E. Effects of sudden changes of temperature on elongation rate of primary root. Bot. Gaz. 99: 196-206. f. 1. 27 S 1937.
- Franck, J. The fundamentals of photosynthesis. Jour. Washington Acad. Sci. 27: 317-329. f. 1-3. 15 Au 1937.
- Frenguelli, J. Variaciones de *Dictyocha fibula* en el golfo de San Matias. An. Mus. Argentino Cienc. Nat. 38: 265-281. pl. 1-14+f. 1. 15 S 1935.
- Friesner, R. C. & Potzger, J. E. Contrasts in certain physical factors in Fagus-Acer and Quercus-Carya communities in Brown and Bartholomew counties, Indiana. Butler Univ. Bot. Stud. 4: 1-12. S 1937.
- Gardner, F. E. & Marth, P. C. Parthenocarpic fruits induced by spraying with growth promoting compounds. Bot. Gaz. 99: 184-195. f. 1-4. 27 S 1937.
 - Giardelli, M. L. Las flores de Wolffiella oblonga. Revista Argentina Agron. 2: 17-20. f. 1-14. Ap 1935.
 - Gill, L. S. Arceuthobium in the United States. Trans. Connecticut Acad. Arts & Sci. 32: 111-245. pl. 3-13+f. 1-12. Jl 1935.
- Oillette, N. J. Morphology of some American species of Psaronius. Bot. Gaz. 99: 80-102. f. 1-20. 27 S 1937.
 - Giusti, L. Experiencias sobre la accion fisiológica de la Wedelia glauca y del Astragalus Bergii. Revista Argentina Agron. 1: 223-228. N 1934.
 - Goodwin, R. H. The cyto-genetics of two species of Solidago and its bearing on their polymorphy in nature. Am. Jour. Bot. 24: 425-432. f. 1-16. Jl 1937.
 - Griggs, R. F. Hybridity as a factor in evolution. Jour. Washington Acad. Sci. 27: 329-343. f. 1, 2. 15 Au 1937.

- Gross, R. Duas Cyperaceas novas do Brasil. Bol. Mus. Nac. Rio de Janeiro. 12²: 75-79. pl. 1, 2. Je 1936.
- Grout, A. J. Moss flora of North America. 1²: 63-135. pl. 39-68. Au 1937.

 Polytrichaceae by T. C. Frye and Calymperaceae by W. C. Steere.
- Guba, E. F. The fungi of Nantucket, Century I. Rhodora 39: 367-376. S 1937.
- Hahn, G. G. Immunity of Viking, a Norwegian red currant, to Cronartium ribicola and C. occidentale under greenhouse conditions. U. S. Dep. Agr. Circ. 330: 1-16. f. 1, 2. Ja 1935.
- Hambleton, S. La vegetacion del Canal y Rio Baker (Patagonia Occidental) Revista Argentina Agron. 3: 159-173. S 1936.
- Hansbrough, J. R. The *Tympanis* canker of red pine. Yale Univ. School Forestry Bull. 43: i-ix+1-58. pl. 1-12+f. 1-3. 1936.
- Harms, H. Araliaceae andinae. Notizbl. Bot. Gart. Berlin 13: 445-448. 30 Je 1937.
- Harms, H. Meliaceae americanae novae. Notizbl. Bot. Gart. Berlin 13: 501-507. 30 Je 1937.
- Hasselberg, G. B. E. Zur morphologie des vegetativen Sprosses der Loganiaceen Symb. Bot. Upsaliensis II. 3: i-vii+1-170. f. 1-173. 1937.
- Heimerl, A. Nyctaginaceae of southeastern Polynesia and other Pacific islands. Bernice P. Bishop Mus. Occ. Papers 13: 27-47. pl. 1-3+f. 1-8. 20 Ap 1937.
- Heinicke, A. J. & Childers, N. F. The daily rate of photosynthesis, during the growing season of 1935, of a young apple tree of bearing age. Cornell Univ. Agr. Exp. Sta. Memoir 201: 1-52. f. 1-10. F 1937.
- Henrard, J. T. A study in the genus Vulpia. Blumea 2: 299-326. 20 Ap 1937.
- Henrard, J. T. Velloziaceae americanae nonnullae novae vel minus cognitae. Blumea 2: 339-384. pl. 1. 20 Ap 1937.
- Hesler, L. R. Notes on southern Appalachian fungi, II. Jour. Tennessee Acad. Sci. 12: 239-254. f. 1-5. Jl 1937.
- Hirschhorn, E. Observaciones sobre la meiosis normal y un caso de asinapsis en Sisyrinchium. Revista Argentina Agron. 1: 66-75. f. 1-24. Je 1934.
- Hoehne, F. C. Orchidaceas dos herbarios de Alexandre Curt Brade e do Museu Nacional. Bol. Mus. Nac. Rio de Janeiro 12²: 1-37. pl. 1-7. Je 1936.
- Hoover, R. F. A new Californian species of *Brodiaea*. Madroño 4: 130-132. f. 1. 4 O 1937.

- Hoover, R. F. A provisional key to the species of *Downingia* known in California. Leafl. West. Bot. 2: 33-35. 26 Au 1937.
- Horovitz, S. & Sanguineti, M. E. Siamensis, nuevo caracter hereditario del maiz. Revista Argentina Agron. 3: 245–249. pl. 13, 14+f. 1. D 1936.
- Howell, J. T. New Californian plants. Leafl. West. Bot. 2: 42-45. 26 Au 1937.
- Hsiong, S. L. & Hildebrand, E. M. Maternal inheritance in pears. Phytopathology 27: 861-862. Au 1937.
- Hulten, E. Südwest-Alaska. Vegetationsbilder 25³: 1-3. pl. 13-18. 1937.
- Hurd-Karrer, A. M. Rubidium and strontium toxicity to plants inhibited by potassium and calcium respectively. Jour. Washington Acad. Sci. 27: 351-353. 15 Au 1937.
- **Jensen, H.W.** Meiosis in several species of dioecious monocotyledoneae I. The possibility of sex-chromosomes. Cytologia Fujii 1: 96–103. f. 1–15. Je 1937.
- **Katznelson, H.** Bacteriophage in relation to plant diseases. Bot. Rev. 3: 499-521. O 1937.
- LaMotte, C. Conditions affecting germination of the megaspores of *Isoetes lithophila*. Am. Jour. Bot. 24: 454-456. Jl 1937.
- Lang, C. H. Investigations of the pollen of the Malvaceae, with special reference to the inclusions. Jour. Royal Microscop. Soc. III. 57: 75-102. f. 1-44. Je 1937.
 - McFadden, G. H. & McMurry, R. L. Rhus glabra. Am. Jour. Pharmacy 109: 397-406. Au 1937.
 - Macht, D. I. & Grumbein, M. L. Influence of indole acetic, indole butyric, and naphthalene acetic acids on roots of *Lupinus albus* seedlings. Am. Jour. Bot. 24: 457-460. Jl 1937.
 - Morse, W. J. & Cartter, J. L. Improvement in soybeans. U. S. Dep. Agr. Yearbook Agr. 1937: 1154-1189. f. 1-9. 1937.
 - Nieves, R. Infeccion experimental del centeno de Petkus por las caries del Trigo. Revista Argentina Agron. 1: 97-110. f. 1. Au 1934.
 - Olmo, H. P. Chromosome numbers in the European grape (Vitis vinifera). Cytologia Fujii 1:606-613. f. 1-5. Je 1937.
 - Pastore, A. I. Estudio microscopico del almidón de plantas alimenticias aborígenes. Revista Argentina Agron. 2: 78-85. f. 1-3. Au 1935.
 - Porterfield, W. M. The periodicity of bamboo culm structures. China Jour. 18: 357-371. f. 1-4. Je 1933.

- Powers, L. & Dahl, A. O. Failure of diakinesis and metaphase pairing and the behavior during meiosis of univalent chromosomes in Zea mays. Jour. Agr. Res. 54: 655-668. pl. 1-4. 1 My 1937.
- Pultz, L. M. Relation of nitrogen to yield of sugar-beet seed and to accompanying changes in composition of the roots. Jour. Agr. Res. 54: 639-654. f. 1-4. 1 My 1937.
- Purvis, E. R. & Ruprecht, R. W. Cracked stem of celery caused by a boron deficiency in the soil. Univ. Florida Agr. Exp. Sta. Bull. 307: 3–16. f. 1–3. Ja 1937.
- Rabinowitsch, B. Observations on the structure of cotton fibers in the dark field. Contr. Boyce Thompson Inst. 8: 401-403. f. 1. Ja-Mr 1937.
- Rawitscher, F. Geotropism in plants. Bot. Rev. 3: 175-194. Ap 1937.
- Read, C. B. The flora of the New Albany shale. Part 2. The Calamopityeae and their relationships. U. S. Dep. Int. Prof. Paper 186-E: 81-104. pl. 16-26+f. 1. 1937.
- Reeves, R. G. & Beasley, J. O. Localization of pentosans in the resin glands of the cotton embryo. Jour. Agr. Res. 54:711-718. 1 My 1937.
- Regan, C. W. Spring flowers of the northern Rockies. Gard. Chron. Am. 41: 141, 142, 148. illust. My 1937.
- Ricker, P. L. The lupines. Wild Flower 14: 32-36. Ap. 1937.
- Rickett, H. W. Erythronium mesochoreum. Rhodora 39: 101-105. illust. 5 Ap 1937.
- Robbins, W. J. The assimilation by plants of various forms of nitrogen. Am. Jour. Bot. 24: 243-250. My 1937.
- Robertson, D. W. Inheritance in barley II. Genetics 22: 443-451. Jl 1937.
- Rodenhiser, H. A. Echinulation of chlamydospores and the pathogenicity of a previously undescribed physiologic race of Sphacelotheca cruenta. Phytopathology 27: 643-645.
- Ruiz, O. M., Levaduras del Mana. An. Inst. Biol. Mexico 7: 77-95. f. 1-6. 1936.
- Salaman, R. N. The potato in its early home and its introduction into Europe. Jour. Roy. Hort. Soc. 62: 112-123. f. 32-37. Mr 1937.
- Sandwith, N. Y. Contributions to the flora of Tropical America: XXX. Kew Bull. Misc. Inf. 2: 100-112. 1937.
- Sandwith, N. Y. Liabum ovatum. Curtis' Bot. Mag. 160: pl. 9485. 8 My 1937.

- Savage, D. A. Drought survival of native grass species in the central and southern Great Plains, 1935. U. S. Dep. Agr. Tech. Bull. 549: 1-54. f. 1-27. Mr 1937.
- Schade, A. L. Observations on a *Monascus* isolated from rubber. Mycologia 29: 295-302. My-Je 1937.
- Schmale, F. Valerianaceae americanae novae. Repert Spec. Nov. 41: 292–295. 25 F 1937.
- Schroeder, E. M. Germination of fruits of *Ptelea* species. Contr. Boyce Thompson Inst. 8: 355-359. Ja-Mr 1937.
- Schuchert, C. David White 1862–1935. Nat. Acad. Sci. Biog. Memoirs 17: 189–221. *illust.* 1936.
- Scully, F. J. Ferns of Hot Springs National Park and vicinity. Am. Fern Jour. 27: 59-62. Ap-Je 1937.
- Sealy, J. R. Penstemon isophyllus. Curtis' Bot. Mag. 160: pl. 9482. 8 My 1937.
- Seaver, F. J. Photographs and descriptions of cup-fungi-XXVII. Pezicula on Cornus. Mycologia 29: 334-337. f. 1, 2. My-Je 1937. XXVIII. A proposed new genus. 678-680. f. 1. N-D 1937.
- Seifriz, W. Die Höhenstufen der Vegetation in der Sierra Nevada von Santa Marta (Colombia). Bot. Jahrb. 68: 113–125. 14 Ap 1937.
- Setchell, W. A. & Gardner, N. L. A preliminary report on the algae. Proc. California Acad. Sci. 22: 65-98. pl. 3-25+f. 1. 29 Ja 1937.

 The Templeton Crocker Exped. of the Calif. Acad. Sci. 1932.
- Sharp, A. J. Notes on ferns of the southern Appalachians. Jour. Tennessee Acad. Sci. 12: 186. f. 1. Ap 1937.
- Shaver, J. M. Vacationing among Tennessee ferns. Am. Fern Jour. 27: 73-90. pl. 4. Jl-S 1937.
- Shear, G. M. Recent additions to the Gray Herbarium from southeastern Virginia—a review. Claytonia 3: 51-53. Ap 1937.
- Sinclair, W. B. & Bartholomew, E. T. Diastatic activity of orange leaves as affected by time, temperature, pH, and certain zinc salts. Jour. Agr. Res. 54: 609-619. f. 1-3. 15 Ap 1937.
- Sinnott, E. W. The relation of gene to character in quantitative inheritance. Proc. Nat. Acad. Sci. 23: 224-227. f. 1. Ap 1937.
- Sisson, W. A. Identification of crystalline cellulose in young cotton fibers by x-ray diffraction analysis. Contr. Boyce Thompson Inst. 8: 389-400. f. 1-3. Ja-Mr 1937.
- Smith, A. C. Three new species of Vacciniaceae. Phytologia 1: 209-212. 14 Je 1937.

Smith, A. H. Studies in the genus *Mycena*. III. Mycologia 28: 410-430. f. 1-3. O 1936; IV. 29: 338-354. f. 1-3. My-Je 1937.

Smith, H. H. Inheritance of corolla color in the cross Nicotiana Langsdorffii by N. Sanderae. Genetics 22: 347-360.

My 1937.

Smith, H. H. The relation between genes affecting size and color in certain species of *Nicotiana*. Genetics 22: 361–375. pl. 1+f. 1-3. My 1937.

Smith, L. B. A new genus of Eriocaulaceae. Contr. Gray Herb. Harvard Univ. 117: 38-39. pl. 2+f. 55-60. 28 Je 1937.

Smith, L. B. Notes on plants of northern Brazil collected by Dr. Francis Drouet. Contr. Gray Herb. Harvard Univ. 117: 33-38. pl. 2. 28 Je 1937.

Smith, L. B. Studies in the Bromeliaceae. VII. Contr. Gray Herb. Harvard Univ. 114: 3-11. pl. 1, 2. 5 O 1936.

Smith, L. B. & Harris, S. K. Notes on South American Orchidaceae. I. Contr. Gray Herb. Harvard Univ. 114: 11-12. pl. 2. 5 O 1936.

Smith, O. F. A leaf spot disease of red and white clovers. Jour. Agr. Res. 54: 591-599. f. 1-4. 15 Ap 1937.

Snedecor, G. W. & Cox, G. M. Analysis of covariance of yield and time to first silks in maize. Jour. Agr. Res. 54: 449-459. f. 1, 2. 1 Ap 1937.

Stacey, J. W. Notes on Carex-IX. Leafl West. Bot. 2: 30-31.

19 Ap 1937.

Stancliff, O. May on Mount Diablo. Am. Bot. 43: 54-57. Ap 1937.

Stanley, W. M. Some biochemical investigations on the crystalline tobacco-mosaic virus proteins. Proc. Am. Phil. Soc. 77: 447-453. pl. 1. 22 Ap 1937.

Stevens, N. E. & Wood, J. I. Recent fluctuations in plant diseases in the United States. Bot. Rev. 3: 277-306. f. 1-18. Je 1937.

Steyermark, J. A. Studies in *Grindelia*. III. Ann. Missouri Bot. Gard. 24: 225-262. f. 1-3. 30 Ap 1937.

Stifler, C. B. A new species of Tuberaceae for America. Mycologia 29: 325-326. My-Je 1937.

Stover, E. L. The embryo sac of *Eragrostis cilianensis* (All.) Link. Ohio Jour. Sci. 37: 172-184. pl. 1-3. My 1937.

Strugger, S. Weitere Untersuchungen über die Vitalfärbung der Plastiden mit Rhodaminen. Flora 31: 324–340. pl. 1+f. 1-4. 25 My 1937.

Sydow, H. & Petrak, F. Fungi costaricenses a cl. Prof. Alberto M. Brenes collecti. Ann. Myc. 35: 73-97. 1937.

- Sykes, G. G. Notes on a trip to Sonora. Desert 9: 55-57. illust. My 1937.
- Thériot, I. Quelques nouveautés pour la flore bryologique du Sud-Amérique. Ann. Crypt. Exot. Paris 8: 135-137. illust. N 1936.
- Thomas, H. E. Rosette or little leaf of fruit trees. Phytopathology 27: 727-729. Je 1937.
- Thomas, R. C. The rôle of certain fungi in the "sick wheat" problem. Ohio Agr. Exp. Sta. Bull. 22: 43-45. Mr-Ap 1937.
- Thomson, J. City weeds. School Nat. League VII. 9: 1-3. illust. My 1937.
- Tiffany, L. H. Brazilian Oedogoniales. Revista Sudam. Bot. 4:5-14. f. 1-6. Ja 1937.
- Torrey, R. H. Dactylina artica in the United States. Rhodora 39:152. 5 Ap 1937.
- Tortorelli, L. A. Glosario de terminos usados en anatomia de Maderas. Rev. Argentina Agron. 4: 51-65. f. 1-41. Mr 1937.
- Totten, H. R., Coker, W. C. & Oosting, H. J. Dr. Thomas Grant Harbison. Jour. Elisha Mitchell Sci. Soc. 52: 140-145. 1936.
- Uphof, J. C. Th. Zur Kenntnis der Biologie von Rhapidophyllum Hystrix (Fraser) Wendl. Ber. deutsch. bot. Gesell. 60: 218-225. f. 1-4. 1937.
- Verrall, A. F. Variation in Fomes igniarius (L.) Gill. Univ. Minnesota Agr. Exp. Sta. Tech. Bull. 117: 1-41. f. 1-14. Ap 1937.
- Verrall, A. F. & May, C. A new species of *Dothiorella* causing die-back of elm. Mycologia 29: 321-324. f. 1-6. My-Je 1937.
- Voelcker, O. J. Self incompatibility in cacao. Sixth Annual Report on cacao Research 1936. 2-5. Gov. Printing Office. Trinidad. 1937.
- Walter, J. M. Variation in mass isolates and monoconidium progenies of *Ceratostomella Ulmi*. Jour. Agr. Res. 54: 509-523. f. 1-6. 1 Ap 1937.
- Walther, E. Echeveria hybrids. Jour. Cactus & Succ. Soc. Am. 8: 191-193. f. 1-3. My 1937.
- Walther, E. Echeveria X set-oliver EW. new hybrid. Jour. Cactus & Succ. Soc. Am. 8: 172-173. illust. Ap 1937.
- Walther, E. Pachyphytum viride, a new species. Jour. Cactus & Succ. Soc. Am. 8: 210-211. illust. Je 1937.

The vascular anatomy and comparative morphology of apocynaceous flowers

Robert E. Woodson, Jr., and John Adam Moore (with plates 3–5 and 72 figures)

Although systematic research in the anatomy of flowers dates from the classic investigations of Philippe Van Tieghem (1875) in the last quarter of the past century, the subject cannot be said to have attained prominence in the field of plant anatomy until approximately the past ten years. Within that period the lively discussions of floral anatomy which have been waged, particularly in England and the United States (Eames, 1931; Saunders, 1925) with respect to the merits or demerits of the polymorphic interpretation of crucifer carpels and those of other families of angiosperms has stimulated research concerning the general vascular structure of the flower in many of the important botanical laboratories of the world. Since the flower has been the principal basis of classification of all modern systems of the flowering plants, it is not unnatural that those botanists whose great desire it is to approach ever closer an approximation of evolution have turned to the research of floral anatomy as a timely and promising means to that end.

When the senior author of these observations commenced the taxonomic study of Apocynaceae somewhat over ten years ago, the first papers concerning floral anatomy had just begun to issue from the laboratories of Professor Eames of Cornell University, shortly to be followed by those of Miss Saunders of Cambridge, England. Such approaches to the study of the flower appeared so attractive and significant that an investigation of the floral anatomy of Apocynaceae was immediately begun. From this beginning an account of the vascular anatomy of the genera Apocynum and Nerium was published in 1930. It was not until several years later that the writer chanced upon a previous and more general account of the floral anatomy of Apocynum by Grelot (1897), with which his views were in general agreement.

In the years that have intervened, flowering material of 39 genera and 60 species of Apocynaceae, representing all subdivisions of the family in its distribution in both hemispheres, has been obtained from living specimens in botanic gardens and in the field through the efforts of the senior author and numerous friends to whom he is greatly indebted. Herbarium specimens, although available for such studies within the natural limitations due to desiccation, were employed only in a few critical genera extremely difficult to obtain in the field, such as the polycarpellary genus [The Bulletin for February (65: 79–134) was issued February 1, 1938]

Pleiocarpa of tropical Africa. In general, serial transverse and longitudinal sections approximately 10μ thick were prepared according to the familiar alcohol-xylol-paraffin schedule, and stained in crystal violet and erythrosin, or fast green and safranin.

During the academic year 1935–36 the senior author of these observations was aided by the technical services of his former student, Dr. John Adam Moore, through a grant of the Science Research Fund of Washington University (St. Louis) provided by the Rockefeller Foundation.

REPRESENTATION OF GENERA AND SPECIES

Names preceded by an asterisk (*) denote material obtained from herbarium specimens; all others obtained fresh, and fixed in formalinacetic-alcohol.

Subfamily PLUMERIOIDEAE

Acocanthera spectabilis Hook.

Allamanda cathartica L.

Amsonia ciliata Walt.

Carissa Carandas L.

C. grandiflora A. DC.

Cerbera Tanghin Hook.

*Cufodontia Stegomeris Woods.

Haplophyton cimicidum A. DC.

Lacmellia edulis Karst.

Lochnera rosea (L.) Reichb.

*Pleiocarpa bicarpellata Stapf

*P. mutica Hook.

Plumeria rubra L.

Plumeriopsis Ahouai (L.) Rusby & Woods.

Rauwolfia tetraphylla L.

Rhazya orientalis (Dcne.) A. DC.

Stemmadenia Alfari (Donn. Sm.) Woods.

S. grandiflora (Jacq.) Miers

S. obovata (Hook. & Arn.) K. Sch.

Tabernæmontana acutissima Muell.-Arg.

T. arborea Rose

T. chrysocarpa Blake

T. Cumingiana A. DC.

T. divaricata R. Br.

Thevetia peruviana (Pers.) K. Sch.

Vinca major L.

V. minor L.

Zschokkea panamensis Woods.

Z. ramosissima Muel.-Arg.

Subfamily ECHITOIDEAE

Adenium coetenium Stapf

Beaumontia grandiflora Wall.

Cycladenia humilis Benth.

Forsteronia viridescens Blake

Funtumia elastica (Preuss) Stapf

Macrosiphonia Brachysiphon (Torr.) Gray

M. Macrosiphon (Torr.) Heller

Malouetia guatemalensis (Muell.-Arg.) Standl.

Mandevilla Bridgesii (Muell.-Arg.) Woods.

M. hirsuta (A. Rich.) K. Sch.

M. illustris (Vell.) Woods.

M. laxa (R. & P.) Woods.

Mascarenhasia elastica K. Sch.

Mesechites trifida (Jacq.) Muell.-Arg.

Nerium Oleander L.

Odontadenia Hoffmannseggiana (Steud.) Woods.

O. Schippii Woods.

Prestonia acutifolia (Benth.) K. Sch.

P. portobellensis (Beurl.) Woods.

Rhabdadenia biflora (Jacq.) Muell.-Arg.

Strophanthus dichotomus A. DC.

S. gratus A. DC.

S. sarmentosus A. DC.

*Thenardia Galeottiana Baill.

Trachelospermum difforme (Walt.) Gray

T. jasminoides (Lindl.) Lem.

Urechites Andrieuxii Muell.-Arg.

Subfamily APOCYNOIDEAE

A pocynum androsaemifolium L.

A. cannabinum L.

Trachomitum venetum (L.) Woods.

GENERAL MORPHOLOGY OF THE FLOWER

The apocynaceous flower is always tetracyclic, and is pentamerous save in three small tetramerous genera. The calyx is barely gamosepalous in the majority of instances, the lobes being cleft nearly to the receptacle. The aestivation is almost invariably imbricated. The chief interest in the calyx of Apocynaceae lies in the frequent presence of small, glandular processes, known as "squamellae," which are found within, at the base of the lobes (cf. figs. 2, 5, 8).

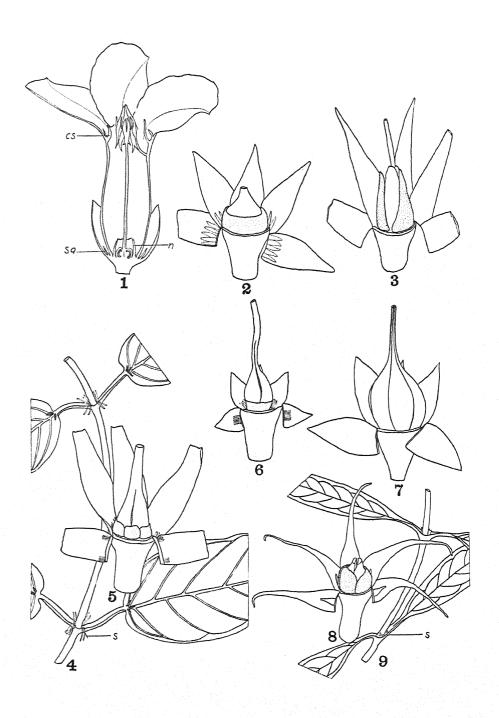
The corolla is gamopetalous and actinomorphic throughout the family, and displays a wide assortment of campanulate, salverform, infundibuli-

form, and rotate modifications. The aestivation is contorted. As in the calyx, the chief interest in the corolla is found in the occasional genera which bear various internal appendages, known as "corolline scales," which form structures strongly reminiscent of the corolline coronas of many Asclepiadaceae (cf. figs. 22, 23, 24). In certain genera, as Strophanthus and Nerium, the corolline scales may be conspicuously exserted and petaloid, while in others, as Apocynum, they may constitute exceedingly inconspicuous, basal emergences which may be observed only after dissection.

The stamens of Apocynaceae are always epipetalous and alternate with the corolline members. Although exceedingly diversified in their morphology and histology, the stamens offer little of interest from the standpoint of vascular anatomy. Nevertheless, the construction and relationship of the anthers has been found extremely practical in the separation of subfamilies: The Plumerioideae are distinguished by anthers without sterile, basal appendages and are not connivent nor agglutinated to the stigma; both the Echitoideae and the Apocynoideae have basally appendiculate anthers which are usually connivent and agglutinated to the stigma through the secretion of certain peculiar, glandular cells. The unique relation of the anthers and stigmata of Echitoideae and Apocynoideae has prompted the suggestion that those families may be more "advanced" than the Plumerioideae, perhaps representing a transition to Asclepiadaceae (Demeter, 1922). Such considerations, however, are without the scope of these studies which are concerned chiefly with vascular anatomy and interpretive gross morphology.

The ovary of Apocynaceae may be either apocarpous or syncarpous. When apocarpous, the ovary is usually bicarpellary, each carpel being infolded at the margins to form an axile, binate placenta. The two free carpels converge at the tips to form a common stylar shaft surmounted by a common, usually rather massive stigma (cf. fig. 1; pl. 5, fig. 6). Among the Apocynaceae with apocarpous ovaries are found a group of three or four genera, designated as the tribe Pleiocarpeae, which are characterized by as many as five free carpels. In such polycarpellary gynoecia each carpel contributes directly to the style and stigma (cf. fig. 7).

Figs. 1-9. Fig. 1., longitudinal section, flower of Prestonia portobellensis: sq—squamella, n—nectary, cs—corolla scales; fig. 2, calyx and gynoecium of Thevetia peruviana; fig. 3, calyx and gynoecium of Lochnera rosea; fig. 4, vegetative branch of Mandevilla Bridgesii: s—stipular appendages; fig. 5, calyx and gynoecium of Mandevilla Bridgesii; fig. 6, calyx and gynoecium of Tabernaemontana chrysocarpa; fig. 7, calyx and gynoecium of Pleiocarpa mutica; fig. 8, calyx and gynoecium of Thenardia Galeottiana; fig. 9, vegetative branch of Thenardia Galeottiana: s—stipular appendages.



Among the syncarpous Apocynaceae both bilocular and unilocular bicarpellary ovaries are encountered. In the bilocular, the placentation of each cavity is axile and binate; in the unilocular ovaries are found two opposed, linear, parietal placentae (cf. pl. 5, figs. 1, 2). In either event the ovary is characterized by a common stylar shaft surmounted by the stigma in the usual manner for the family.

From the standpoint of these investigations, the chief interest in the gynoecium of Apocynaceae is found in the cycle of "nectaries" or "disc lobes" which surrounds the ovaries of many genera. These structures are usually more or less fleshy, and adopt a variety of modifications: chiefly as clusters of discrete bodies, two to five in number (cf. figs. 3, 5), or as collar-like or sleeve-like rings of tissue (cf. figs. 2, 6), about the base of the ovary. Although smaller than the carpels which they surround in most cases, the nectaries occasionally simulate the carpels not only in general shape, but in size as well. Although they frequently are more or less adnate to the ovary, they are always free from the style.

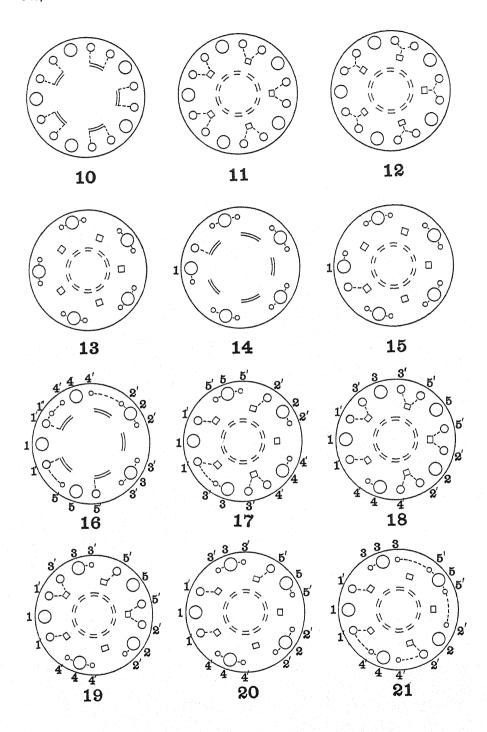
Although appearing to be quite superior in ordinary dissections, the ovaries of many Apocynaceae are more or less "subinferior," or immersed for a short distance within the receptacle. In the genera *Plumeria* (pl. 5, fig. 5) and *Himatanthus* this immersion is found to a marked degree, almost rendering the gynoecium completely inferior.

In order to avoid needless repetition, observations on the floral anatomy of the genera and species will be considered, not separately, but under headings of the various component structural units, such as pedicel, calyx, corolla and androecium, and gynoecium. This method not only is convenient but is justifiable since the flower, considered anatomically, is a condensed short shoot system bearing at the nodes appendages of differing structural and functional modifications.

ANATOMY OF THE PEDICEL

The pedicel of all known Apocynaceae contains an amphiphloic siphonostele (pl. 3, fig. 1) agreeing in general with that of the young stem. The internal phloem of certain genera demonstrates in the pedicel and receptacular stele a marked tendency to separate into small strands which leave the inner face of the protoxylem, from which they are frequently

Figs. 10-21. Calyx anatomy of various Apocynaceae: calyx midribs indicated by large circles, calyx laterals by smaller circles, corolla midribs by squares, residual stele by double arcs, derivation of traces by broken single lines, centripetal succession of calyx lobes by numerals: fig. 10, Lacmellia edulis; figs. 11-12, Mandevillas ubsagittata; figs. 13-14, Mandevilla hirsuta; fig. 15, Tabernaemontana chrysocarpa; fig. 16, Thevetia peruviana; figs. 17-21, Rauwolfia tetraphylla.



isolated by a few cells of basic parenchyma, and invade the pith, where they branch and anastomose irregularly (pl. 3, figs. 1, 2) as described by Scott and Brebner (1891) for the stems or roots of certain Gentianaceae, Apocynaceae, Asclepiadaceae, Solanaceae and Plumbaginaceae. In the apocynaceous flowers which we have investigated, it may be observed usually that the invasion of the pith by strands of internal phloem is perhaps most accentuated immediately before the departure of the calycine traces, after which the former are eliminated either by recombination with the normal internal phloem or by passage and combination outward with the traces to the calyx.

The internal phloem of apocynaceous flowers apparently consists chiefly of protophloem parenchyma, with but few poorly developed sieve tubes. The parenchyma is so similar in appearance to poorly developed provascular tissue that it scarcely comes as a surprise to find that in some cases it may behave similarly to the latter in differentiating into isolated, spiral tracheids (pl. 3, fig. 2). This phenomenon has been found in the pedicels not only of such Apocynaceae as Tabernaemontana acutissima, Stemmadenia grandiflora, and Odontadenia Schippii, but occasionally in certain gentianaceous flowers as well. The provascular tendency of the internal phloem of the pedicellar stele is quite probably to be correlated with the appearance of "meristems producing secondary, medullary wood" discovered by Scott and Brebner (1891) in the stems of Apocynum cannabinum L., Willughbeia firma Bl. (Apocynaceae), and Periploca graeca L. (Asclepiadaceae).

Similar to the internal phloem, the external phloem evidently consists principally of parenchyma in the pedicel. The outer is more uniform than the inner, however, and maintains its position immediately external to the xylem.

The pedicellar wood consists chiefly of protoxylem with a relatively scant development of metaxylem and secondary xylem. Vessels apparently are never present, and the secondary walls of the tracheids are either spiral or annular. Fibers never occur such as have been found in the flowers of certain Gentianaceae (Woodson, 1936).

The organization of latex tissues within the pedicel, as within the flower as a whole, is extremely diversified, to such an extent that observations concerning the laticiferous, storage, and secretory systems will be ignored in this account, possibly to be treated more fully in a subsequent paper.

VASCULAR ANATOMY OF THE CALYX

In the lower receptacle of all apocynaceous flowers the pedicellar stele, usually roughly circular in outline at first, becomes more or less sharply

5- or 10-lobed. In the former case, the lobes are identical with the decurrent midribs of the five calyx lobes. Alternating with these five lobes, the five additional in the 10-lobed stele indicate in most instances the positions of the corolline midribs (cf. fig. 53). As one would expect, the first series of traces to depart from the pedicellar stele are those destined to supply the calyx. For general purposes the calyces of all known Apocynaceae may be divided into four types of organization with respect to their nodal anatomy:

Type I. In the calyces included under Type I the midribs depart from the receptacular stele leaving in each case a single gap. Then, before the stele has again united, the margins of the five gaps give off a single trace, ten in all, which are the lateral traces of the calyx lobes (fig. 10). These lateral traces are therefore coherent to the margins of the gaps left in the stele by the departure of the calyx midribs, and the nodal anatomy in each case is essentially a 3-trace, 1-gap system. Both midrib and laterals soon give rise to small subsidiary veinlets of decreasing magnitude as they progress toward the tips of the calyx lobes.

Various modifications of the typically symmetrical nodal anatomy obtain, frequently in different flowers from the same inflorescence. For example, the lateral traces of each calyx lobe may depart from the receptacular stele to which they are coherent somewhat before the departure of the midribs. Occasionally one margin of the gap left by a midrib may produce no lateral trace, giving rise to a 2-trace condition which may proceed to the tip of the calyx lobe.

The condition of this type may be recognized as basically 3-trace, 1-gap, with the laterals coherent separately to the margins of the midrib gaps before the organization of the corolline traces. It appears probable, in view of the widespread opinion that the 3-trace condition is primitive for both vegetative and floral appendages (Sinnott, 1914; Eames, 1931), that the apocynaceous calyces included within Type I are the most "primitive" from the structural standpoint. It is interesting to note in this connection that the vegetative nodes of all known Apocynaceae produce a single trace from which the laterals are subsequently derived.

Genera and species showing various modifications of the Type I calyx vascular skeleton include:

Lacmellia edulis Karst.

Malouetia guatemalensis (Muell.-Arg.) Standl.

Stemmadenia Alfari (Rose) Woods.

S. grandiflora (Jacq.) Miers

S. obovata (Hook. & Arn.) K. Sch.

Tabernaemontana acutissima Muell.-Arg.

T. arborea Rose.

Features of vascular organization in varying extents similar to Type I, but which are asymmetrically combined with other types, will be discussed under Type IV. It may be of phylogenetic significance that all the genera enumerated above are referable to the subfamily Plumerioideae, save *Malouetia*, which is ordinarily included within the Echitoideae although it was placed in an intermediate position by Mueller (1860).

Type II. The second type of calyx, with respect to vascular anatomy, includes those species in which the lateral traces of the lobes are adnate to the base of the corolline midribs. In this type, the departure of the calyx midribs is immediately followed by the organization of the five midribs to the corolla lobes. Soon after the differentiation of the corolline midribs from the receptacular stele, the adnation of the calyx laterals is terminated, and either the two laterals of adjacent calyx lobes depart separately from the single, alternate corolla midrib (fig. 11), or the two cohere mutually for a short distance after their common severence from the corolline trace (fig. 12). When the calyx laterals are adnate separately to the corolline midrib or cohere mutually for a short distance appears relatively insignificant, as the two conditions may be found usually in the same species, if more than one specimen be examined.

Type II is significant, however, in so far as the 3-trace condition found in Type I evidently is more elaborate, progressing from cohesion to the receptacular stele proper to adnation to the corolla midrib. Genera and species illustrating various modifications of the Type II calyx skeleton include:

Amsonia ciliata Walt. Carissa Carandas L. C. grandiflora A. DC. Forsteronia viridescens Blake Funtumia elastica (Preuss) Stapf Haplophytum cimicidum A. DC. Lochnera rosea (L.) Reichb. Mandevilla subsagittata (R. & P.) Woods. Rhabdadenia biflora (Jacq.) Muell.-Arg. Rhazya orientalis (Dcne.) A. DC. Tabernaemontana Cumingiana A. DC. T. divaricata R.Br. Thenardia Galeottiana Baill. Trachelospermum difforme (Walt.) Gray T. jasminoides (Lindl.) Lem. Urechites Andrieuxii Muell.-Arg. Vinca major L. V. minor L.

If this enumeration is compared with the classification of the Apocynaceae studied during this investigation (p. 136), it will be seen that the genera included above are referable to both subfamilies Plumeroideae and Echitoideae in equal proportions.

Type III. The simplest type of vascular anatomy found in apocynaceous calyces is found in Type III, in which each calyx lobe is strictly 1-trace. This midrib departs from the receptacular stele quite regularly, later giving rise to laterals upon either side, in a manner which is predominant amongst the majority of Gamopetalae (fig. 13). This simple calyx skeleton is found throughout the various taxonomic divisions of the Apocynaceae, and is quite possibly more "advanced" phylogenetically than either Type I or Type II. Genera and species illustrating this type include:

Adenium coetenium Stapf Allamanda cathartica L. A pocynum androsaemifolium L. A. cannabinum L. Cerbera Tanghin Hook. Cycladenia humilis Benth. Mandevilla hirsuta (A. Rich.) K. Sch. M. illustris (Vell.) Woods. M. splendens (Hook.) Woods. Meschites trifida (Jacq.) Muell.-Arg. Nerium Oleander L. Pleiocarpa bicarpellata Stapf P. mutica Benth. Plumeria rubra L. Plumeriopsis Ahouai (L.) Rusby & Woods. Prestonia acutifolia Benth. P. portobellensis (Beurl.) Woods. Strophanthus dichotomus A. DC. S. gratus A. DC. S. sarmentosus A. DC. Tabernaemontana chrysocarpa Blake Trachomitum venetum (L.) Woods.

Even this type is not entirely free from variation, however, since occasionally a single lateral is found to proceed from either the margin of the gap left in the receptacular stele by the departing calyx midrib (fig. 14) as in Type I, or from the corolline midrib (fig. 15) as in Type II.

Type IV. For the purpose of exposition, Type IV is most easily considered after the three preceding types. Actually, however, it is intermediate between all three, incorporating features of Types I and III, or

of Types II and III. In this type of calyx skeleton the vascular supply to the five lobes is distinctly asymmetrical, certain of the lobes receiving their traces according to Type I or Type II, and the others according to Type III. Something of phylogenetic value may be adduced from the fact that the outer lobes are more prone to Types I or II than are the inner, which are somewhat more likely to show Type III (figs. 16–21 inclusive).

The impetus to this condition may be the strong imbrication of the calyx lobes of many genera and species, the inner frequently being more or less completely enclosed within the outer, the two series becoming somewhat different in appearance. This tendency is well marked in the genus *Odontadenia*, and culminates in the remarkable calyx of *Cufodontia*, unparalleled amongst known Apocynaceae (in which the two or three outer lobes become connate, completely hiding the smaller pair within).

Genera and species showing various modifications of the Type IV calyx skeleton include:

(Combination of Types I and III)

Beaumontia grandiflora Wall.

Macrosiphonia Brachysiphon (Torr.) Gray

Mascarenhasia elastica K. Sch. Odontadenia Hoffmannseggiana (Steud.) Woods.

O. Schippii Woods.

Thevetia peruviana (Pers.) K. Sch.

Zchokkea panamensis Woods.

Z. ramosissima Muell.-Arg.

(Combination of Types II and III)

Mandevilla Bridgesii (Muell.-Arg.) Woods.

M. laxa (R. & P.) Woods.

Rauwolfia tetraphylla L.

The vagaries of this type may be illustrated best by a few individual species, considering a single flower for each. For, as will be shown in the case of *Rauwolfia tetraphylla*, one may obtain almost any conceivable mixture of the types by examining a number of flowers from a single inflorescence.

Thevetia peruviana (fig. 16). Outermost calyx lobe (1)¹ similar to Type I, with the laterals cohering to the margins of the midrib gap, but each lateral branching within the receptacle to form the adjacent laterals of the neighboring lobes (4-5). Of the remaining lobes, two (2-3) are essentially like Type III, giving rise to their own laterals, but in the case of one of

¹ The parenthetical numerals refer to the succession of lobes as visualized in the ideographs, progressing centripetally, from 1 to 5.

these (2), one forks to give rise to the lateral of the lobe to the left (4), similarly to the type of cohesion seen in the outermost lobe (1). In the case of the innermost lobe (5) one lateral is produced from the adjacent lateral of the outermost lobe, while the other coheres to the margin of the midrib gap according to the situation found in Type I. In this flower of *Thevetia*, therefore, an odd mixture of Types I and III exists in addition to three puzzling instances of cohesion of adjacent laterals of neighboring lobes.

Rauwolfia tetraphylla (figs. 17–21 inclusive). The variation shown in calyces of the Type IV vascular system is well shown in Rauwolfia tetraphylla. From a single inflorescence of this species preserved in alcohol for the senior writer by the late Dr. N. L. Britton upon his last trip to Puerto Rico, twelve flowers were selected for comparison. Each of these twelve calyces demonstrated a different combination of Types II and III, together with cohesions similar to those found in Thevetia peruviana.

Five variations of the calyx skeleton of this species are diagrammed in figures 17–21 inclusive. In figure 17 a peculiar cohesion is illustrated involving the right (as seen from within) lateral of lobe 1, with the left lateral and the midrib itself of the adjacent lobe 3. A precisely similar cohesion is found in figure 21 involving lobes 1 and 4; furthermore this skeleton is complicated by cohesions involving the adjacent right and left laterals of lobes 2 and 4 respectively, while the laterals of lobe 5 are both coherent to the laterals of adjacent lobes 3 and 2.

The striking variability of the calyx anatomy of Type IV genera and species is somewhat of a deterrent to the direct correlation of vegetative and floral nodal anatomy. At the same time, an impetus should be given to the study of variation in floral anatomy, a field that has appeared to at least some observers to be in imminent danger of "too easy" interpretations. On the other hand, the derivation of the 1-trace from the basic 3-trace condition is decidedly clarified by the very existence of transitions.

THE NATURE OF THE CALYCINE SQUAMELLAE

The most interesting feature of the apocynaceous calyx from the standpoint of comparative morphology is the occurrence of the internal glands, or "squamellae." The position, numbers, and aspect of these small structures are sufficiently constant and characteristic to be of importance taxonomically. There are three chief categories of squamellae with respect to their relationships with the calyx lobes which they subtend: alternate with the lobes, upon the margins of which they appear to be attached, either singly or in groups (fig. 5), opposite the lobes, solitary (fig. 8) or

in groups (fig. 6), or *indefinitely distributed*, when they seem to form a fringe of many individuals uniformly distributed around the very base of the calyx (fig. 2). Although squamellae are frequent in the family, they are occasionally lacking (figs. 3, 7).

It is significant to note that the vegetative nodes of most Apocynaceae also bear small, frequently glandular structures at the base of the petioles. As in the squamellae, these nodal appendages may be either alternate, opposite, or indefinitely distributed with respect to the petiole. Although the Apocynaceae are usually considered as an exstipulate family, these appendages are doubtless in the category of stipules, following the interpretation of Glück (1919). As one studies the Apocynaceae, one cannot fail to observe the fact that the position of the squamellae with respect to the calyx lobe is in most cases quite similar to that of the appendages of the vegetative node with respect to the petiole (cf. figs. 4, 5; 8, 9). One would be justified in assuming from this evidence the two categories to be equivalent, and the calycine squamellae as stipules.

This observation upon gross morphology is substantiated materially by studies of microscopic anatomy. As seen in longitudinal (pl. 3, fig. 7) or transverse section (pl. 4, fig. 6), the squamellae are found to consist of a small core of somewhat elongated cells continuous with the mesophyll of the calyx lobe which they subtend, surrounded by a glandular epidermis of horizontally compressed cells usually containing a nucleus in the region nearest the "core." Vascular tissue usually is lacking, but in such species as Strophanthus gratus (pl. 4, fig. 6) and Funtumia elastica (pl. 4, fig. 5) small bicollateral bundles derived from the marginal venation of the calyx lobe are found to be present, simulating the vascular supply of many stipules (Sinnott and Bailey, 1914). Both from the standpoint of gross morphology and from the vascular anatomy of certain species, therefore, the stipular nature of the squamellae appears well substantiated.

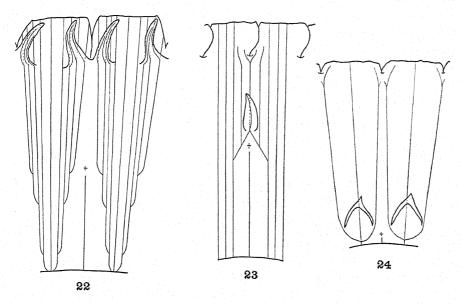
As in the case of normal, marginal stipules, the alternate type of squamellae would appear basic. The solitary, opposite squamellae would appear to have been derived by the fusion of two marginal squamellae in a position adaxial to the calyx lobe which they subtend. Evidence to support this assumption is found in serial sections of such a flower as that of Mandevilla subsagittata (pl. 4, figs. 3–4), in which the very base of the opposite squamella is found to be bipartite and related to the margins of the calyx lobe. The indefinitely distributed squamellae are explainable with justification merely by assuming the developmental laceration of either alternate or opposite members.

The foliar nature of the calycine squamellae of Apocynaceae therefore appears fairly obvious, according to Glück's (1919) observations from

gross morphology, and in contradiction to Woodson's (1930) previous interpretation of these organs as possibly staminodia, a position, adopted entirely upon the basis of adenopetaly in double flowers of *Nerium Oleander*, which must now be discarded.

VASCULAR ANATOMY OF COROLLA AND ANDROECIUM

The nodal anatomy of the corolla of Apocynaceae is relatively simple. To each of the normally five lobes of the gamopetalous corolla a single trace departs from the receptacular stele after the differentiation of the calycine midribs. Almost at the same time five alternate traces are produced for the five epipetalous stamens. An exception to this general con-



Figs. 22-24. Morphology and vascular anatomy of the corolla scales of certain Apocynaceae: fig. 22, Strophanthus sarmentosus; figs. 23, Prestonia portobellensis; fig. 24, Apocynum androsaemifolium. The point of attachment of stamens is indicated as +

dition is found in the investigated species of Apocynum and Trachomitum (figs. 53–57 inclusive), both members of the subfamily Apocynoideae, in which the staminal traces are briefly adnate to the midribs of the opposite calyx lobes.

The chief feature of interest as far as the general vascular anatomy of the corolla is concerned is the adnation of the calyx laterals to the corolline midribs in certain genera and species, which already has been discussed. Lateral venation is obtained in the corolla merely by the more or less frequent branching of the midrib. The staminal bundles remain unbranched throughout their adnation to the corolla as well as throughout the staminal filaments and the anthers.

The curious anatomy of the anthers is a topic of interest because of the extreme variation of cellular modification. Since this subject deals exclusively with modifications of the fundamental tissues, however, it will be deferred for the present, perhaps to be treated in a future paper on the reproductive mechanism of the family.

THE NATURE OF THE COROLLINE SCALES

The chief morphological interest in the corolla of Apocynaceae lies in the faucal appendages or "corolline scales" occasionally found within the gamopetalous tube. These appendages frequently are showy and laminate, forming a fringe or "corona" within the throat of the corolla from which they may be widely exserted. In such genera as *Strophanthus* (fig. 22) these scales occur in pairs alternate with the corolla lobes. In *Prestonia* (fig. 23) a single appendage occurs immediately above the insertion of the stamens. In *Apocynum* (fig. 24) they are inconspicuous and scale-like, and adnate to the base of the corolla tube and opposite the lobes.

The corolline scales of apocynaceous corollas apparently are never glandular, the organization of the fundamental tissues being in all essential respects similar to that of the corolla proper. Furthermore certain of the scales, such as those of *Apocynum* and *Trachomitum*, contain no vascular tissue, and one might be led to consider them simply as emergences of no particular morphological significance. In the majority of such appendaged corollas, however, the presence of well developed vascular tissues may be proved, and the skeletal relationship of the appendages and the corolla proper easily observed by clearing the whole corolla in lactic acid. Diagrams of segments of three representative corollas treated in this manner are provided in figures 22–24 inclusive.

Strophanthus sarmentosus (fig. 22) possesses paired faucal appendages alternate with the corolla lobes. In cleared corollas the vascular bundles traversing each appendage are found to be derived from the outermost lateral veins of the adjacent corolla lobe. Furthermore it is found that the traces entering the appendage are merely branches of the corolline laterals which proceed up into the corolla lobe. When compared with the gross morphology and vascular anatomy of such a stipulate node as that of Pelargonium (Sinnott and Bailey, 1914) it appears obvious that the corolline scales of Strophanthus must be interpreted as stipules.

An interesting modification of the corolline appendage is found in species of *Prestonia* (fig. 23), which is solitary and alternate with the

corolla lobes. In the case of *P. portobellensis* a single vascular strand is found within the scale. But this strand has been formed by the fusion of branches from the outermost lateral vein of both adjacent corolla lobes, the veins themselves continuing up into the respective corolla lobes. This condition is decidedly similar to that of the single interpetiolar stipules of many Rubiaceae. Far from being an "exstipulate family," therefore, the Apocynaceae are seen to bear stipules not only at the vegetative nodes, but subtending the members of both calyx and corolla as well. Both the calyx and the corolla of this family are evidently foliar.

VASCULAR ANATOMY AND COMPARATIVE MORPHOLOGY OF THE GYNOECIUM

The gynoecium of Apocynaceae is more diversified than is generally understood. Normally it is bicarpellary, the ovary proper being apocarpous or syncarpous. When apocarpous, each carpel possesses an infolded, marginal placenta bearing few to numerous ovules. When syncarpous, the component carpels may adhere more or less closely by their commisural margins, but maintaining their individuality to create a bilocular ovary, each loculus containing an axile, binate placenta similar to that found in apocarpous ovaries (pl. 5, fig. 1).

When unilocular, however, the ovary contains two parietal placentae oriented horizontally to the position of the two axile placentae of the bicarpellary ovary (pl. 5, fig. 2). In frequent instances one finds that a syncarpous ovary is bilocular at both base and apex, where placentation is axile, but unilocular in the middle where placentation is parietal. The natural inference from such a simple observation is that the unilocular condition has been derived from the bilocular phylogenetically as well as ontogenetically, by the cohesion of contiguous placental margins of the component carpels, and the separation of the component halves of the erstwhile binate placentae. The simple process by which this coexistent cohesion and separation may be accomplished is obvious when one observes in bilocular, syncarpous ovaries that the closely appressed epidermal layers of the infolded margins composing the axile placentae of either carpel retain their distinction long after the epidermis separating the two carpels themselves has been obliterated.

Another proof of the two parietal placentae as consisting of fused halves of adjacent axile placentae is found in the orientation of the vascular bundles contained within the common stylar shaft uniting the carpels. The styles of bicarpellary Apocynaceae invariably contain two separate bundles which are the prolongations of the respective carpellary midribs. In the styles of bilocular ovaries the orientation of the bundles

is in the same diameter with respect to the axile placentae (cf. figs. 51–52; 71–72), but invariably at a deviation of roughly 90° with respect to the parietal placentae (cf. figs. 69–70). This simple observation should at once explain the derivation of parietal from axile placentae and confound the attempt to explain the "commisural stigma" upon the basis of "carpel polymorphism (Saunders, 1925)."

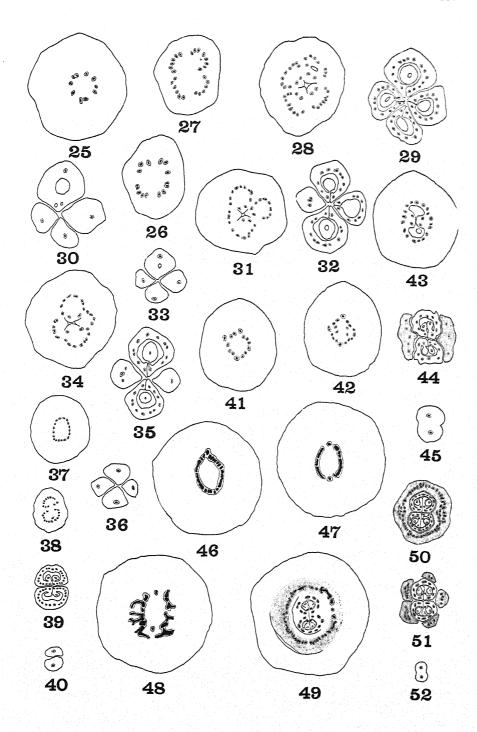
Although predominantly bicarpellary, the Apocynaceae include a few polycarpellary genera constituting the tribe Pleiocarpeae of the subfamily Plumerioideae. The number of carpels in this tribe varies from two to five, the whole range being encountered amongst different species of the single African genus *Pleiocarpa* (fig. 7). In some species of *Pleiocarpa* the number of fertile carpels tends to vary, as will be shown presently. The ovary of all polycarpellary genera always is apocarpous, but the component carpels are united by a rather poorly organized style within which the number of vascular bundles corresponds (cf. figs. 29, 33).

Surrounding the ovary of Apocynaceae one usually finds a cycle of fleshy bodies known as "nectaries" or "disc lobes." The nectaries frequently are separate, and two to five in number (figs. 3, 5), but occasionally they cohere to form a nearly uniform, annular structure (figs. 1, 2, 6). Occasionally the nectaries are quite as massive as the carpels, which they simulate in general aspect save for the fact that they do not contribute to the style (figs. 3, 8).

That the nectaries definitely are appendages and not merely meaningless hypertrophies of the receptacle is demonstrated by the fact that they contain definite vascular tissue associated with that of the gynoecium proper. The fundamental tissue comprises an elaborate assortment of secretory and storage cells a comprehensive discussion of which is without the scope of this paper (cf. pl. 3, figs. 6, 7; pl. 5, fig. 3). After a study of the floral anatomy of *Apocynum*, Woodson (1930) concluded that the nectaries of Apocynaceae should be interpreted as carpellodes. That position may now be given support by a study of numerous additional genera, particularly the polycarpellary species *Pleiocarpa mutica*.

The vascular anatomy of the ovaries and associated nectaries of all genera and species studied during the present investigations may be treated by representative illustrations which follow.

Figs. 25-52. Vascular anatomy of the gynoecium of Apocynaceae, traces to the perianth and stamens omitted. Explanation in the text. Figs. 25-36, *Pleiocarpa mutica*; figs. 37-40, *P. bicarpellata*; figs. 41-45, *Lochnera rosea*; figs. 46-52, *Mandevilla subsagittata*. In these diagrams glandular tissue pertaining to the nectaries is stippled.



Pleiocarpa

It has been impossible to obtain fresh material of the interesting genus *Pleiocarpa*. The genus is relatively poor in herbarium representation as well. However, three flowers were removed from a herbarium specimen of *P. mutica* Benth., and prepared in serial sections after softening in "diaphanol" according to a method outlined in a previous account by the senior writer (Woodson, 1935). It is interesting to observe that these flowers constituted a cymule, the first flower to be observed being the central member.

Flower 1 (figs. 25–30 inclusive). After the departure of the perianth and stamen traces, the receptacular stele is found to consist of approximately 10 to 20 small bundles assuming a roughly circular orientation (fig. 25). Four adjacent pairs of these, situated at regular intervals within the stele, migrate toward the center, and are subsequently found to be the placental bundles of the four component carpels (figs. 26, 27). This interpretation shortly is proved by the appearance of ovary cavities and the subsequent separation of the carpels from the receptacle (figs. 28, 29). It is not until after the full organization of the carpels that the respective midribs become obviously distinct from the sessile secondary venation. In this flower all four carpels are hollow and fertile.²

Flower 2 (figs. 31–33 inclusive). After the departure of the perianth and staminal bundles, the residual receptacular stele consists as in the first flower of about 10–20 bundles arranged in a circle. Two pairs of these migrate toward the center, but the remaining two pairs observed in the previous flower are represented merely by a single bundle for each, which likewise migrate centripetally (fig. 31). It is not surprising, therefore, to find that subsequent events produce but three hollow carpels, only two of which, incidentally, are ovuliferous. The fourth carpel of the first flower is replaced by a solid carpellode (fig. 32). Both the sterile carpel and the solid carpellode contribute their midribs to the style, however, and can scarcely be considered as precisely equivalent to "nectaries" (fig. 33).

Flower 3 (figs. 34–36 inclusive). In this flower the residual stele of the receptacle consists, as before, of about 10–20 bundles. Four solitary, equidistant bundles migrate centripetally (fig. 34), and it is found subsequently that the ovary consists of two hollow, ovuliferous carpels alternating with two solid carpellodes which have been supplied by the arcs of bundles intervening between the pairs of placental traces (fig. 35). As in the second

² The use of the terms "hollow," "fertile," "sterile," and "solid" are used here strictly in a descriptive sense and without the specialized meanings of the writers on "carpel polymorphism" (Saunders, 1925).

flower, the carpellodes contribute their midribs to the style (fig. 36).

In the three flowers of a single cymule of *Pleiocarpa mutica*, therefore, a striking tendency to the reduction of the number of fertile carpels is found. In *P. bicarpellata* Stapf sections of several flowers have revealed but two (fertile) carpels in each case, and without any indication whatever of carpellody (cf. figs. 37–40 inclusive). The anatomy of these ovaries is essentially similar to that of *Cerbera Tanghin*, which will be explained subsequently.

Lochnera

The two ovuliferous carpels of several genera and species of Apocynaceae alternate with as many fleshy nectaries. A good illustration of this condition is Lochnera rosea (figs. 41–45 inclusive). In this species, as in Pleiocarpa mutica, the residual stele of the receptacle consists of about 20 bundles. As in the third flower of P. mutica also (fig. 34), four equidistant bundles migrate centripetally to produce the placental bundles of the two ovuliferous carpels; the two arcs of bundles intervening supply the two alternating nectaries (figs. 42–44). These true nectaries differ from the solid carpellodes observed in the third flower of Pleiocarpa mutica only in so far as they do not contribute to the style (fig. 45). Nevertheless the true nectaries of Lochnera and the solid carpellodes of Pleiocarpa are almost exactly similar as far as their vascular origin is concerned, and their position also argues in favor of their relationship.

It appears obvious that the nectaries of *Lochnera* should be considered as carpellodes, and this interpretation extends itself to other nectaries of Apocynaceae. Other species possessing two nectaries of an anatomical organization essentially similar to that of *Lochnera rosea* include:

Vinca major L. V. minor L.

Mandevilla

The vascular organization of the ovary and nectaries of Mandevilla subsagittata (R. & P.) Woods. (figs. 46-52 inclusive) is representative of all investigated species of Mandevilla and several closely related genera. In this species the receptacular stele unites after the departure of the corolline and staminal traces, a rare phenomenon amongst the Apocynaceae that have been investigated (fig. 46). The stele is somewhat elliptical in section, and very shortly the midribs of the two carpels depart by gaps from the opposite, narrowed ends of the ellipse (fig. 47). Meanwhile, the two broad arcs of the stele branch outward into an aggregate of separate bundles (fig. 48). The stele is now completely disrupted into

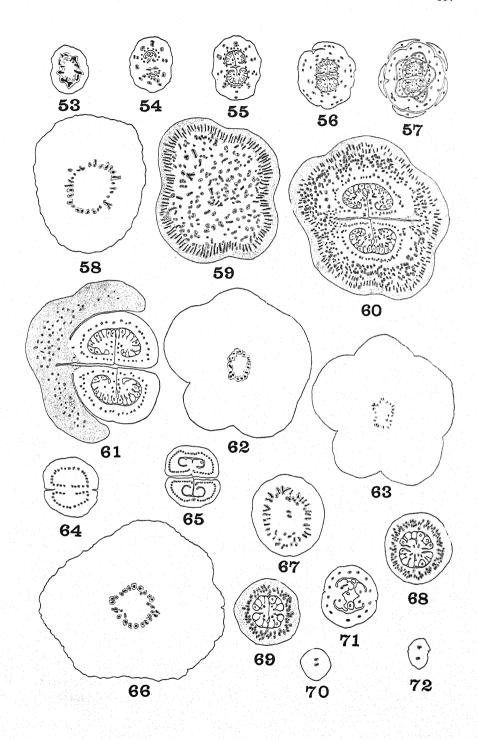
bundles of varying size, but all smaller than the two opposed midribs which have remained unbranched.

Centripetal migration of four to eight bundles roughly equidistant from the midribs now takes place to form the lateral bundles of each carpel. The organization of the carpels and the nectaries now takes place with the peripheral residual bundles supplying the latter (figs. 49, 50). The nectaries of this species, which superficially appear to be five in number in ordinary dissections, are found to be united at the base. Very shortly after their organization from the receptacle and the gynoecium proper, radial division of the bundles, occuring first in two planes alternate with the two carpels, produces something of a "polydesmic" condition, which is continued for a short space even after the organization of the five separate nectary lobes (figs. 50, 51).

The nectaries of M. subsagittata and its congeners, as well as those of other genera having this type of gynoecial anatomy, are usually five in number. But whether the gross aspect of the bodies should be taken as indicating the sterilization of five separate carpels, or whether the fact that the vascular supply of the cycle of nectaries has its origin in a somewhat similarly bilateral fashion to those of Lochnera is an indication that here also but two carpellodes are involved, is not wholly decided by the evidence, although the latter appears probable. Evidence to support the latter assumption may be found in the fact that only two nectary lobes are found in several species of Mandevilla, such as M. splendens (Hook). Woods., and M. illustris (Vell.) Woods. The 5-lobed condition in M. subsagittata and other species might be interpreted as an instance of ontogenetic schizogeny due to internal pressures within the developing pentamerous flowers. The annular nectary of several species of Odontadenia, such as O. Hoffmannseggiana (Steud.) Woods. is cleft into almost innumerable tooth-like segments whose number is certainly not indicative of the number of carpellodes actually involved.

In any event, the vascular supply of the nectaries of M. subsagittata differs from that of Lochnera chiefly in its adnation to the lateral bundles of the carpels; and the nectaries here as well are evidently to be considered as carpellodes. Other genera and species having a gynoecial skeleton similar to that of M. subsagittata include:

Figs. 53-72. Vascular anatomy of the gynoecium of Apocynaceae, traces to the perianth and stamens omitted save in figs. 53-57. Explanation in the text. Figs. 53-57, Apocynum cannabinum; figs. 58-61, Stemmadenia Alfari; figs. 62-65, Cerebera Tanghin; figs. 66-70, Lacmellia edulis; figs. 71-72, Allamanda cathartica. In these diagrams glandular tissue pertaining to the nectaries is stippled.



Macrosiphonia Brachysiphon (Torr.) Gray

M. Macrosiphon (Torr.) Heller

Mandevilla Bridgesii (Muell.-Arg.) Woods.

M. hirsuta (A. Rich.) K. Sch.

M. illustris (Vell.) Woods.

M. splendens (Hook.) Woods.

Mascarenhasia elastica K. Sch.

Mesechites trifida (Jacq.) Muell.-Arg.

Essentially the same vascular organization is found in numerous other species and genera, which differ chiefly in that the residual stele consists of separate bundles, rather than a siphonostele:

Allamanda cathartica L.

Forsteronia viridescens Blake

Lacmellia edulis Karst.

Malouetia guatemalensis (Muell.-Arg.) Standl.

Odontadenia Hoffmannseggiana (Steud.) Woods.

O. Schippii Woods.

Plumeriopsis Ahouai (L.) Rusby & Woods.

Prestonia acutifolia (Benth.) K. Sch.

P. portobellensis (Beurl.) Woods.

Rauwolfia tetraphylla L.

Rhabdadenia biflora (Jacq.) Muell.-Arg.

Thenardia Galeottiana Baill.

Thevetia peruviana (Pers.) K. Sch.

Trachelos permum difforme (Walt.) Gray

T. jasminoides (Lindl.) Lem.

Urechites Andrieuxii Muell.-Arg.

Zschokkea panamensis Woods.

Z. ramosissima Muell.-Arg.

In certain of the foregoing, repeated radial and tangential branching of the nectary bundles produces an elaborate "polydesmic" condition; in certain also the centripetal migration of the four placental bundles may occur before the branching outward of the nectary traces. In some, the four placental laterals may fuse into pairs composed of the adjacent laterals of either carpel, later dividing again before the complete organization of the ovary (cf. figs. 67–69 inclusive). But such variations may be encountered occasionally within flowers of a single species, and thus appear relatively insignificant.

Stemmadenia

The most elaborate and confusing system of vascular supply for the gynoecium is found in the investigated species of *Stemmadenia* and certain

more or less closely related genera. In S. Alfari (cf. figs. 58-61 inclusive), the departure of the corolline and staminal bundles leaves an elaborately dissected residual stele composed of many bundles uniseriately arranged in roughly circular outline (fig. 58). These commence an extended system of branching, both radially and tangentially, until the stele consists of innumerable strands occupying the receptacle in a manner almost "monocotyledonous" (fig. 59).

At no time are the midribs and placental laterals distinguishable as such. Nevertheless a definitely glandular development of the outermost tissue strongly suggests the adnation of an annular nectary to which the outermost vascular bundles probably are referable.

The scattered bundles merely crowd away to allow the formation of the carpellary cavities; after which those which are to supply the carpels are definable by forming an invaginated arc about the two cavities. The bundles other than this single series proceed up into the nectaries, which remain adnate to the ovary save very shortly at the upper margins (figs. 60, 61). "Polydesmy" therefore frequently is characteristic of the nectaries, and never of the carpels proper.

Other species having a gynoecial anatomy similar in general to that of S. Alfari include:

Funtumia elastica (Preuss.) Stapf

Stemmadenia grandiflora (Jacq.) Miers

S. obovata (Hook. & Arn.) K. Sch.

Tabernaemontana acutissima Muell.-Arg.

T. arborea Rose

T. chrysocarpa Blake

T. Cumingiana A.DC.

T. divaricata R.Br.

Cerbera

The vascular anatomy of apocynaceous ovaries which are unaccompanied by nectaries shows great uniformity. That of *Cerbera Tanghin* Hook. (figs. 62–65 inclusive) may illustrate this group. After the departure of the corolline and staminal traces the receptacular stele is seen to constitute a hollow cylinder consisting of several distinct bundles, or rarely a poorly organized siphonostele which soon becomes dissected (fig. 62). At this stage the midribs ordinarily are not obvious as such.

Soon, however, the number of bundles increases by tangential branching, and the stele thus increased undergoes a furrowing in two opposed positions to form the vascular supply of the respective carpels (figs. 63, 64), the cavities of which shortly make their appearance. By this time

the carpels are organized fully, and the midribs usually are somewhat larger than the lateral veins, but never is this difference very pronounced (fig. 65). As appears to be invariable in the Apocynaceae, the midribs proceed into the common style, the lateral traces disintegrating distally. Other genera and species which are destitute of gynoecial nectaries and show an ovarian anatomy similar to that of *C. Tanghin* include:

Adenium coetenium Stapf
Amsonia ciliata Walt.
Cycladenia humilis Benth.
Haplophyton cimicidum A.DC.
Nerium Oleander L.
Pleiocarpa bicarpellata Stapf
Plumeria rubra L.
Rhazya orientalis (Dcne.) A.DC.
Strophanthus dichotomus A.DC.
S. gratus A.DC.
S. sarmentosus A.DC.

Although the foregoing appear superficially to be destitute of a nectary about the ovary, and no vascular tissue to supply such an organ exists, several genera (cf. *Cycladenia*) possess carpels which are united for a short distance at the very base, where a rather poorly defined glandular development of the superficial tissues occurs.

Apocynum

The vascular anatomy of the gynoecium of *Apocynum* and *Trachomitum*, both members of the small subfamily *Apocynoideae*, differs so markedly from that of other members of the Apocynaceae, and is so closely involved with the vascular skeleton of the other components of the flower, that it appears necessary to present a condensed account of the anatomy of an entire, representative flower (cf. figs. 53–57 inclusive).

The stele of Apocynum cannabinum is rather irregularly 10-lobed in the lower receptacle (fig. 53). Of the ten, alternate lobes depart to provide the midribs of the five calyx and corolla members, and from each the respective laterals are produced according to the Type III calyx plan. As the perianth midribs depart they leave in their wake a rather indefinite number of small, poorly defined bundles to constitute the residual stele. Two opposed pairs of these bundles migrate toward the center of the stele to form the placental bundles of the two carpels in a manner similar to that observed for Pleiocarpa, Cerbera, and other genera. The residual stele remaining after the departure of the perianth traces, therefore, is devoted solely to the vascular supply of the two carpels.

Subsequent to their departure from the receptacular stele, however, it is found that the ten "perianth traces" are really compound structures. For the five staminal traces prove to be adnate to the calycine midribs; and, furthermore, the corolline midribs are found to be adnate to the five bundles which supply the five gynoecial nectaries (figs. 54–57) inclusive. The five nectary midribs, upon becoming free from the corolline midribs, branch tangentially to produce a somewhat variable number (usually two) of laterals. Full tissue differentiation of the calyx, corolla (with the epipetalous staminal filaments), nectaries, and carpels is obtained at about this time.

This curious adnation of the staminal to the calycine traces, and of the nectary to the corolla traces, has been observed only amongst the following genera and species, all of which are referable to the subfamily Apocynoideae:

Apocynum androsaemifolium L.

A. cannabinum L.

Trachomitum venetum (L.) Woods.

The most striking and significant feature of this type of gynoecial skeleton is found in the fact that the carpellary and nectary vascular supplies are quite independent, removing as well the possibility of interpreting the nectaries as merely "enlargements of the receptacle or torus," and of no evolutionary significance.

EVOLUTIONARY MODIFICATION OF THE GYNOECIUM

We have observed that in *Pleiocarpa mutica* there can be found in a single cymule an almost perfect transition from four fertile carpels to two fertile carpels and two alternate, solid carpellodes. It has also been pointed out that the two nectaries which alternate with the fertile carpels of *Lochnera* and *Vinca* differ from the solid carpellodes of *Pleiocarpa* only in the fact that they do not contribute to the style. The "nectaries" certainly appear to be equivalent to the "carpellodes" both from the observed variation in *Pleiocarpa* and from the standpoint of comparative vascular anatomy. If the interpretation of the gynoecial nectaries as carpellodes be accepted, phylogenetic significance will be given to the diversity of modification amongst the nectaries, and to their various relationships to the ovary proper. A few Apocynaceae are polycarpellary at the present day; but the frequency of nectaries amongst the family as a whole would indicate polycarpy to have been the original condition probably throughout, or essentially so.

In many Apocynaceae the nectaries are completely free from the

ovary. But in others they are found to be adnate to the very base of the ovary. In certain genera and species the nectaries are adnate throughout their entire length, or free merely at their upper margins (cf. Stemmadenia, figs. 60, 61). When the adnation of an annular nectary is virtually complete, its presence may be determined superficially only by the somewhat enlarged, glandular base of the ovary (cf. pl. 5, fig. 4). When seen in transverse section, however, two more or less distinct vascular systems frequently are found, the outer pertaining to the adnate nectary, and the innermost to the carpels (cf. pl. 5, figs. 1, 2). That the cohesion and subsequent adnation of the cycle of nectaries may influence syncarpy of the ovary is indicated by the fact that in most syncarpous ovaries the presence of an adnate nectary cycle may be demonstrated, either by a glandular base of the ovary wall, or that together with a double vascular supply.

In some cases, as in *Cycladenia humilis*, the ovary may be syncarpous and bilocular for the basal half roughly, and apocarpous above. In such ovaries, although a second vascular system cannot be demonstrated, the syncarpous base is conspicuously glandular; and one easily assumes that although the nectary vascular supply has been eliminated the effects of adnation remain in the syncarpy and the glandular epidermis of the ovary base. It should be observed that this interpretation receives support from the fact that obviously simple, apocarpous ovaries of Apocynaceae never are provided with a glandular epidermis.

The peculiar adnation of the nectaries to the ovary of certain Apocynaceae recalls the current theory of "carpel polymorphism" (Saunders, 1925). And surely it appears that that theory should rest upon some such foundation as that found in Apocynaceae. But the observations which we have made necessitate no specious assumptions of "valve" and "solid" carpels, either "sterile" or "fertile," in confusing variety, the fallacy of which has been revealed so satisfactorily by Eames (1931). We wish to emphasize that our conception of the carpel is that of Eames and not of Saunders (1925). This may be effected most expeditiously, perhaps, by adding that Miss Saunders has expressed privately to the senior author that it is her conviction that the ovary of Apocynum consists of at least six carpels; two "sterile valves" plus four "fertile, solid carpels"; and that the nectaries are merely enlargements of the receptacle and of no particular significance.

DISCUSSION AND SUMMARY

Perhaps the chief interest in the floral morphology and anatomy of Apocynaceae is found in the interpretation of three categories of structure which are presumed to be vestigial: 19381

- (1). The calycine squamellae are small internal appendages at the base of the calyx lobes which are sufficiently constant in position, shape and number to form the basis of taxonomic differentiation of genera and species. These appendages usually are glandular and without vascular tissue. In a few genera, however, they are provided with small traces produced from the lateral veins of the calvx lobes. Therefore they are interpreted as stipular vestiges. Similar calycine appendages are found in certain other families of Gamopetalae. In one genus of Asclepiadaceae they have been construed as stipular in nature (Woodson, 1936) and future studies may lead to a similar interpretation in such families as Gentianaceae, Oleaceae, etc.
- (2). The corolline scales likewise are internal appendages of the corolla which are of considerable taxonomic value. Where they are well developed these scales are found to have an interesting vascular anatomy, with the traces supplied as branches from the corolla lateral veins in a manner very similar to that found in many vegetative stipules such as those of Pelargonium. The corolline scales therefore also are interpreted as stipules. Various "coronas" and "scales" are found upon the petals of many flowering plants, such as Caryophyllaceae, Gentianaceae, Asclepiadaceae, etc. Subsequent investigations may well reveal these, also, as stipular vestiges and the corolline members as essentially foliar in nature.
- (3). The gynoecial nectaries constitute a cycle of two to five more or less fleshy, ovoid bodies about the base of the ovary. Occasionally the nectaries cohere to form an annular structure. Previous studies by the senior author (Woodson, 1930) had shown the vascular organization of these structures to be rather similar to that of the fertile carpels. In the present investigations an almost perfect transition from four fertile carpels to two fertile carpels and two alternate solid carpellodes has been demonstrated to occur in a single cymule of Pleiocarpa mutica. The nectaries of other Apocynaceae, such as Vinca and Lochnera, differ from the carpellodes of *Pleiocarpa* essentially only in the fact that they do not contribute to the style. Hence the interpretation of the nectaries as carpellodes finds additional support.

In some genera a peculiar condition is found in which the nectaries cohere mutually and become adnate to the functional ovary, giving rise to a phenomenon which the writers wish to emphasize as not coinciding with the theory of "carpel polymorphism." Apocynaceous ovaries of several genera which appear to be simple from ordinary dissections are found to bear rather obscure traces of such nectarian adnation.

The interpretation of the nectaries as constituting a cycle of carpellodes apparently would indicate the derivation of Apocynaceae from polycarpellary ancestors; and the presence of stipular vestiges in the calyx and corolla, as well as at the vegetative node, might indicate a phylogenetic relationship with the extant order Rosales. Similar gynoecial nectaries occur in other families of Angiospermae such as Caryophyllaceae, Primulaceae, Gentianaceae, Convolvulaceae, Solanaceae, Caprifoliaceae, etc. and probably would repay similar study. The hypogynous "disc" of Mertensia (Boraginaceae) recently has been interpreted as of carpellode origin by the junior author (Moore, 1936).

The vascular anatomy of the calyx is found to be of interest in that there is an apparent transition from the 3-trace unilocular to the 1-trace condition of the lobes. Although four general types of organization are encountered predominantly, an almost bewildering variation occurs, oc-

casionally amongst flowers of a single inflorescence.

Although we believe that contributions of some value have been made to the phylogeny of Apocynaceae through our investigations, it must be granted that the results appear to be of little value to pure taxonomy. The vascular systems of the calyx, for example, do not coincide in general with existing classifications, and neither do they support the erection of a more satisfactory system. It probably should be assumed that the present systematic divisions of the family, which appear fairly natural upon their basis of gross morphology, are of great antiquity and have undergone parallel evolution of a certain degree.

Missouri Botanical Garden, Washington University, Saint Louis, Mo.

Huron College, Huron, S. D.

Literature cited

Demeter, K. 1922. Vergleichende Asclepiadeenstudien. Flora 115: 130-176.
Eames, A. J. 1931. The vascular anatomy of the flower with refutation of the theory of carpel polymorphism. Amer. Jour. Bot. 18: 147-188.

Gluck, H. 1919. Blatt- und Bluthenmorphologische Studien. Jena.

Grelot, P. 1897. Recherches sur le systeme libero-ligneux floral des gamopetales bicarpellaires. Ann. Sci. Nat. Bot. ser. 8. 5: 1-154.

Moore, J. M. 1936. Morphology of the gynobase in *Mertensia*. Amer. Midl. Nat.

17: 749-752.

Mueller, J. 1860. Apocynaceae, in Martius, Flora Brasiliensis, vol. 6.

Saunders, E. R. 1925, et seq. On carpel polymorphism, I. Ann. Bot. 39: 123-167.

Scott, D. H., and Brebner, G. 1891. On internal phloem in the root and stem of dicotyledons. Ann. Bot. 5: 259-300.

Sinnott, E. W. 1914. The anatomy of the node as an aid in the classification of the angiosperms. Amer. Jour. Bot. 1: 302-322.

- _____. and Bailey, I. W. 1914. Nodal anatomy and the morphology of stipules. Amer. Jour. Bot. 1: 441–453.
- Van Tieghem, P. 1875. Recherches sur le structure du pistil et sur l'anatomie comparée de la fleur. Mém. Sav. Acad. Sci. Inst. Imp. France 21: 1-261.
- Woodson, R. E., Jr. 1930. Studies in the Apocynaceae, I. Ann. Missouri Bot. Gard. 17: 1-212.
 - ——. 1935. The floral anatomy and probable affinities of the genus Grise-bachiella Lorentz. Bull. Torrey Club 62: 471-478.
- ——. 1936. Observations on the floral fibres of certain Gentianaceae. Ann. Bot. 50: 759-766.

Explanation of plates

(All photomicrographs from transverse sections unless otherwise stated)

PLATE 3

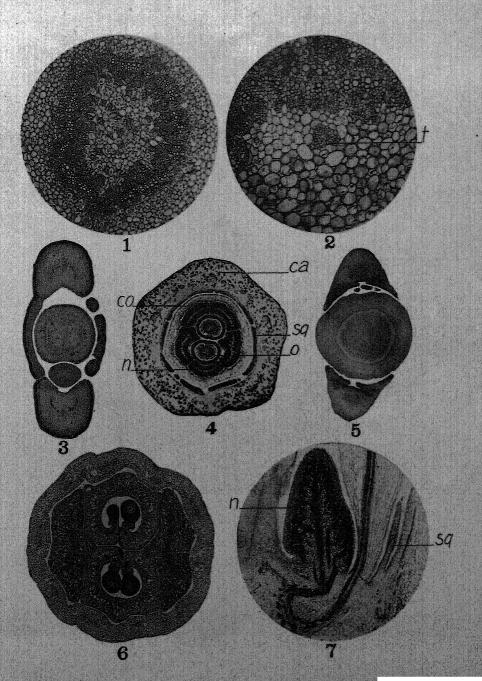
- Fig. 1. Pedicel of Rauwolfia tetraphylla L., showing invasion of the pith by strands of internal phloem. (×45)
- Fig. 2. Same as fig. 1, showing trached of protoxylem (t) differentiated within a medullary strand of internal phloem. $(\times 230)$
- Fig. 3. Vegetative node of *Mandevilla Bridgesii* (Muell.-Arg.) Woods., showing origin of interpetiolar stipular appendages. (×16)
- Fig. 4. Flower of *Mesechites trifida* (Jacq.) Muell.-Arg., general morphology: ca—calyx tube; co—corolla tube; sq—squamellae; n—nectaries; o—ovary. (×12)
- Fig. 5. Vegetative node of *Prestonia acutifolia* (Benth.) K. Sch., showing origin of intrapetiolar stipular appendages. (×16)
- Fig. 6. Flower of *Vinca minor* L., showing carpels and alternate nectaries. (\times 28) Fig. 7. Sector of flower of *Mandevilla subsagittata* (R. & P.) Woods., longitudinal section, showing nectary (n) and squamella (sq). (\times 28)

PLATE 4

- Fig. 1. Sector of flower of *Mesechites trifida* (Jacq.) Muell.-Arg., showing marginal origin of squamellae (sq) ($\times 50$)
- Fig. 2. Sector of flower of *Mandevilla Bridgesii* (Muell.-Arg.) Woods., showing squamellae (sq). $(\times 50)$
- Figs. 3-4. Sector of flower of *Mandeville subsagittata* (R. & P.) Woods., showing marginal origin of "opposite" squamellae. (×50)
- Fig. 5. Sector of flower of Funtumia elastica (Preuss) Stapf, showing migration of squamella traces (st) from the calyx. (\times 50)
- Fig. 6. Squamella of Strophanthus gratus A. DC. showing bicollateral trace (st) derived from calyx. ($\times 210$)

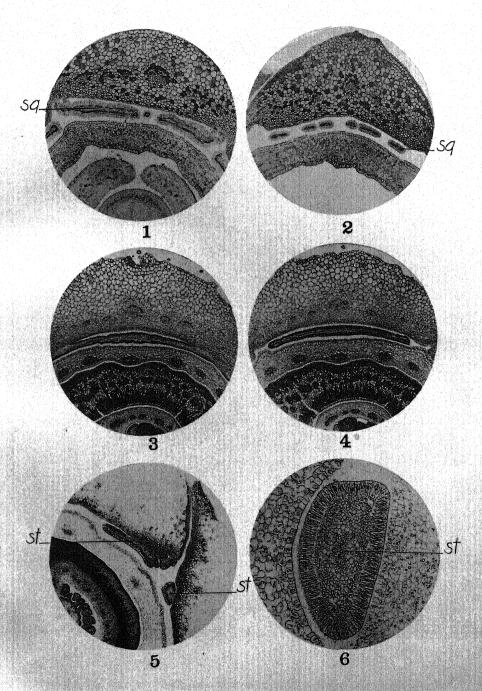
PLATE 5

- Fig. 1. Ovary of Zschokkea panamensis Woods, showing adnation of the annular nectary. The vascular systems of the nectary (nt) and the ovary proper (ot) remain distinct. The ovary is syncarpous but bilocular with axile placentation. $(\times 17)$
- Fig. 2. Ovary of Lacmellia edulis Karst. showing adnation of the annular nectary. The vascular systems of the nectary (nt) and the ovary proper (ot) remain distinct. The ovary is syncarpous and unilocular with parietal placentation. $(\times 17)$
- Fig. 3. Sector of flower of *Mandevilla subsagittata* (R. & P.) Woods., showing annular base of the nectaries which are free from the carpels which they surround. $(\times 20)$
- Fig. 4. Sector of flower of Tabernaemontana chrysocarpa Blake, longitudinal section, showing adnation of the annular nectary (n). $(\times 25)$
- Fig. 5. Sector of flower of *Plumeria rubra* L., longitudinal section, showing the almost completely inferior ovary. (×25)
- Fig. 6. Sector of flower of *Urechites Andrieuxii* Muell.-Arg., longitudinal section, general morphology: ca—calyx; sq—squamella; co—corolla; a—anther; s—stigma; o—ovary; n—nectary. (×25)



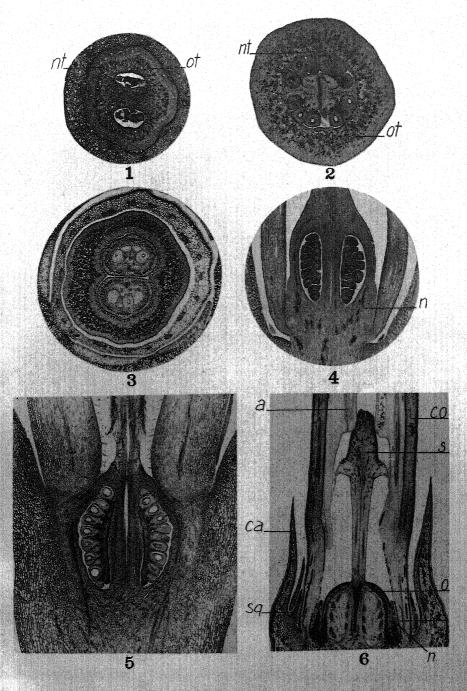
WOODSON AND MOORE: APOCYNACEAE





WOODSON AND MOORE: APOCYNACEAE





WOODSON AND MOORE: APOCYNACEAE



Notes on fungi from the lower Mississippi Valley¹

L. O. OVERHOLTS (WITH FIGURES 1-13)

From July until October of 1931 the writer was in the employ of the office of Forest Pathology of the United States Department of Agriculture. Most of this period was spent in a reconnaissance survey of timber decays and their causal fungi as they occur in the hardwood forests of the lower Mississippi Valley. Most of the time was spent in northeastern Louisiana in the region adjacent to the towns of Lake Providence and Ferriday, from which points excursions were made into adjacent Arkansas and Mississippi. About 500 collections of fungi, representing approximately 200 species, mainly of wood-inhabiting forms, were made and subsequently determined. These form the basis of the present report.

In the course of these investigations the writer was accompanied at times by members of the Forest Pathology division of the Southern Forest Experiment Station at New Orleans, and throughout the summer by Mr. Frank Kaufert without whose assistance the list would be much less complete. In the identifications I have had also considerable assistance from Mr. Ross W. Davidson of the Washington Office of Forest Pathology. Dr. C. L. Shear and Miss Edith K. Cash have made some identifications of collections falling into their special fields. Several collections of resupinate Hymenomycetes still remain to be determined, but it is impossible, because of the existing chaos in the genera to which they belong, to complete them at this time.

The generally dry atmospheric conditions which had prevailed during the preceding two years was both an advantage and a handicap; the former because it enabled us to penetrate swamp lands that normally are more inundated and inaccessible, and the latter because of its probable effect in reducing the number of species and collections obtained. This last item was in part overcome by the fact that during the summer of 1931 itself, rains, though not always heavy, were frequent enough during July and August to produce at least a fair crop of sporophores.

Viewed against a background of collecting in the wooded areas of the Allegheny Mountains the bottom hard-wood lands along the lower Mississippi River present some interesting contrasts. In the *Polyporaceae* there is the usual abundance of sap-wood inhabiting species, and the usual paucity of sporophores of heart-wood decaying species, or if sporo-

¹ Authorized for publication on Jan. 5, 1938, as paper No. 818 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Contribution No. 103 Department of Botany, The Pennsylvania State College, State College, Pa.

phores of the latter group are slightly more abundant it may be due to the presence of certain species inclined to fruit more prolifically, and seldom found in the Allegheny region. But in other families the differences are more striking, if one may consider the summer of 1931 as approaching normality. One is particularly impressed by the lack of both individuals and species in the families Agaricaceae, Boletaceae, and Clavariaceae. While little attempt was made to collect specimens in these groups except for wood-inhabiting Agaricaceae, very few species were encountered. The Russulae and Lactariae that occur so abundantly in favorable seasons in the Allegheny region seem rare indeed, and terrestrial species of other genera were rarely seen. A single bolete, *Boletus chrysenteron* was common enough, but few others were seen. In the Clavariaceae not a single specimen was observed. Terrestrial Hydnaceae were likewise absent. In the Thelephoraceae, the wood-inhabiting species seemed fairly common, but here again terrestrial forms were rare.

In the Polyporaceae new information has been obtained on a considerable number of species. The status of Polyporus ludovicianus, a little known species, has been cleared up, and the species shown to be of great importance in causing an extensive butt-rot in Quercus and Liquidambar. It fruited abundantly and it is surprising that it has so long remained obscure. P. fissilis was collected in abundance and likewise proved to be highly important in the pathology of both Quercus and Liquidambar. An extensive and highly characteristic large pocket rot of Quercus is now rather definitely attributed to P. zonalis although some further study of that species is highly desirable in the light of the fact that essentially the same rot occurs in much more northward stations, apparently attributable to either or both Poria undata and Polyporus rigidus, all of which, however, have sporophores that are very similar in their essential characters. P. sulphureus seems to be just as ubiquitous in Louisiana as in more northern regions, while P. dryophilus and P. dryadeus, long known for their heart-rotting propensities in northern oaks, are strangely uncommon or occur not at all in this region. P. lucidus has been shown to be the cause of extensive heart decays in living Quercus, and this information came as a considerable surprise. P. hispidus is common on living Quercus and likewise causes an extensive and rather important decay, and as seems to be true in the north, is usually associated with the occurrence of conspicuous elongated wounds or cankers. P. palustris seems to cause an extensive brown heart-rot in living pine, and this relationship has not previously been reported. The same is true for Fomes Calkinsii, or its near relative F. robustus, on Quercus, but the species is probably not so

important. No additional information was secured as to the cause of "pecky cypress" but it is a safe assumption that it is not caused by *Fomes geotropus* as has been stated.

Owing to the fact that the relatively small amount of collecting that has previously been done in this region has not emphasized the pathological aspects of the situation, much new information has been secured as to generic substrates of numerous species of timber-inhabiting fungi. Most of this, together with additional notes, will be presented with each species.

Specimens of a considerable number of the species collected are deposited at the Southern Forest Experiment Station in New Orleans. A larger and nearly complete representation of species has been deposited in the office of Forest Pathology at Washington. A nearly complete representation of both species and collections is in the writer's herbarium, while certain duplicates have been filed in the herbarium of the Pennsylvania State College.

While considerable collecting was done in each of the states of Louisiana, Mississippi, and Arkansas, the species listed are to be regarded as originating in Louisiana unless otherwise specified by state abbreviations.

ASCOMYCETES

Bolinia tubulina (A. & S.) Sacc. on Gleditsia. Cenangella Ravenelii (Berk.) Shear on Ilex. Daldinia concentrica (Bolt.) Ces. & deNot. on Diospyros. Dothichloe atramentosa (Berk. & Curt.) Atk. on Sporobolus Berteroanus. Hypocrea rufa (Pers.) Fr. on Quercus; H. sulphurea (Schw.) Sacc. on Liquidambar. Hypoxylon atropunctatum (Schw.) Cooke on Fagus; H. botrys Ell. & Ev.; H. haematostromum Mont.? on Fraxinus; H. rubiginosum (Pers.) Fr. Lachnum virgineum (Batsch) Karst.? on Taxodium. Nectria sanguinea (Bolt.) Fr. on Liquidambar. Nummularia clypeus (Schw.) Cooke. Phyllachora graminis (Pers.) Fuckel on Panicum. Rhytisma acerinum (Pers.) Fr. on Acer rubrum; R. Vaccinii (Schw.) Aut. Am. on Vaccinium arboreum (La., Miss.). Taphrina caerulescens (Mont. & Desm.) Tul. on Quercus nigra.

FUNGI IMPERFECTI

Cercospora rhoina Cooke & Ellis on Rhus (Miss.). Darluca filum (Biv.) Cast. on Melampsora Medusae on Populus deltoides (La.) and on Uromyces Lespedezae-procumbentis on Lespedeza repens (Miss.). Dendrochium compressum Ell. & Ev. Dendrostilbella sp. on Celtis. Endothiella gyrosa Sacc. on Quercus. Phyllosticta acericola Ell. & Ev. on Acer rubrum; P. Labruscae Thuem. on Vitis. Septoria Rubi var. pallida Ell. & Holw. on Rubus.

BASIDIOMYCETES

ORDER I. USTILAGINALES

Entyloma australe Speg. on Physalis. (Ark.)

ORDER II. UREDINALES

Coleosporium Solidaginis (Schw.) Thuem. on Solidago; C. Vernoniae Berk. & Curt. on Vernonia. Gymnosporangium germinale (Schw.) Kern on Pyrus (Miss.). Melampsora Humboldtiana Speg. on Salix; M. Medusae Thuem. on Populus deltoides. Phakopsora Crotonis (Burr.) Arth. on Croton capitatum. Puccinia Hydrocotyles (Link) Cooke on Hydrocotyle; Puccinia Polygoni-amphibii Pers. on Polygonum; P. Smilacis Schw. on Smilax; P. Xanthii on Xanthium (Miss.). Uromyces Lespedezae-procumbentis (Schw.) Curt. on Lespedeza repens (Miss.); U. Toxicodendri Berk. & Rav. on Rhus Toxicodendron.

ORDER III. HYMENOMYCETALES FAMILY AURICULARIACEAE

Auricularia Auricula-Judae (Fr.) Schroet. on Celtis, Gleditsia, Liquidambar and Quercus; common, with some specimens as much as 25 cm. broad (La., Ark.); A. rosea Burt. Septobasidium pseudopedicellatum Burt on Crataegus; S. retiforme (Berk. & Curt.) Pat. on Quercus.

FAMILY TREMELLACEAE

Eichleriella Leveilliana (Berk. &. Curt.) Mont. on Crataegus. Exidia alba (Lloyd) Burt. Sebacina incrustans (Pers.) Tul. on dead Vitis and at bases of living Cornus and other shrubs. Tremellodendron pallidum (Schw.) Burt.

FAMILY DACROMYCETACEAE

Calocera cornea (Batsch) Fries on Gleditisa. Ceracea corticioides Ellis on Taxodium. Guepinia spathularia (Schw.) Fr. on Liquidambar and Taxodium.

FAMILY THELEPHORACEAE

Aleurodiscus acerinus (Pers.) Hoeh. & Lit. on Quercus. Asterostroma cervicolor (Berk. & Curt.) Massee on Planera, Quercus, and other hardwoods. Coniophora olivascens (Berk. & Curt.) Massee on Populus deltoides. Corticium chrysocreas (=Odontia Archeri); C. galactinum (Fr.) Burt on Pinus taeda; C. lactescens Burt? on Celtis; C. lividum Pers. on Quercus (La., Ark.); C. portentosum Berk. & Curt. on Gleditsia; C. stramineum Bres. Hymenochaete Curtisii (Berk.) Morg. on Quercus marylandica; H. epichlora (Berk. & Curt.) Cooke. Peniophora carnea (Berk. & Curt.) Cooke on Celtis;

P. cremea Bres. on Crataegus; P. gigantea (Fr.) Massee on Pinus; P. Roumeguerii Bres. on Acer rubrum, Carya, Crataegus, Diospyros, Quercus (La., Ark.). Stereum fasciatum Schw. on Quercus (La., Miss.); S. frustulosum Pers. on Quercus; S. fuscum (Schrad.) Quel. on Acer, Celtis, Fraxinus Quercus, and Ulmus (La., Ark.); S. gausapatum Fr. on Quercus (Ark.); S. pargamenum Berk. & Curt. (Fig. 4); S. rameale (Schw.) Fr. on Cephalanthus, Quercus (La., Ark.); S. Ravenelii Berk. & Curt.; S. subpileatum Berk. & Curt. on Liquidambar and Quercus (La., Ark.); S. umbrinum Berk. & Curt.

FAMILY HYDNACEAE

Hydnum ochraceum (Pers.) Fr. on Liquidambar, Nyssa, Quercus (La., Miss.); H. pulcherrimum Berk. & Curt. on Liquidambar and Quercus (La., Ark.). Irpex cinnamomeus on Quercus; I. mollis Berk. & Curt. on Liquidambar, I. Ravenelii Berk. on Quercus. Odontia barba-Jovis Fries; O. brunnescens n. sp. on Liquidambar; O. ciliolata (B. & C.) Miller; O. farinacea (Pers.) Bres; O. fimbriata (Pers.) Fr.; O. macrodon (Pers.) Bourd. & Galz.; O. setigera (Fr.) Miller on Liquidambar, Planera, Ulmus. Radulum vinosum n. sp.

Of the above species the following are worthy of further comment:

Hydnum pulcherrimum was one of the commonest fungi encountered. It is a sessile, white, soft species growing on logs and stumps or on wounded areas of living trees and specimens up to 15 cm. broad. Fresh specimens have a milky juice that becomes very sticky as it dries (fig. 2).

Odontia brunnescens n. sp. Resupinate, effused, membranous or subceraceous, with a thin pruinose-agglutinated margin of pale cream color; hymenium not cracked, cream-buff to clay color or pale cinnamon (Ridgway) when dry, thickly set with dome-shaped or slightly elongate protuberances that are separate or slightly confluent, projecting 80-250 µ above the surface, broad and obtuse, barely visible to the unaided eye; in section with a slightly yellowish subiculum 60-80μ thick, composed of a narrow and scarcely discernible substratal layer of horizontal hyphae from which arises a broader and very compact central region of sub-erect hyphae with a narrow incrusted layer along its lower edge and sometimes with some incrustation above, bearing the basidial layer; cystidia of two types, one projecting on the granules and between them, with sub-bulbous base and tapering and sharp-pointed apex, 4-6 μ diameter below and there rarely slightly incrusted, the other especially abundant in the granules, imbedded or reaching the level of the basidial layer, never conspicuous, incrusted, hyaline, $35-40\times9-10\mu$; spore short-cylindric, smooth, hyaline, $4-6 \times 2-3\mu$.

On dead branch of Liquidambar. Type collected at Oak Grove, La., Aug. 17, 1931. (U.S.F.P. Herb. 50225; Overholts Herb. 15252) (figs. 1, 3).

The granules on the hymenial surface are broader than in most species of *Odontia*, but the presence of cystidia precludes reference of the plant to the genus *Grandimia*.

Odontia fimbriata (Pers.) Fries. On dead wood. Wildsville, La.

Radulum vinosum n. sp. Resupinate, effused for several centimeters, thin and adnate, without definite margin; hymenium with rather blunt teeth that are isolated or closely associated, up to 1 mm. long and $150-300\mu$ diameter, everywhere vinaceous-drab or fawn color on drying; in section showing a distinct subiculum $200-300\mu$ thick, composed of somewhat gelatinized and very densely arranged hyphae throughout, those toward the substratum subhorizontal and those toward the hymenium sub-erect, no incrustation, apparently about $3-4\mu$ diameter and without cross-walls or clamps though too strongly gelatinized and agglutinated to be certain; basidia $2-3\mu$ diameter; spores allantoid, bacilliform, smooth, hyaline, $3-4\times1\mu$; cystidia and gloeocystidia absent; crystals about 20μ diameter scattered through the subiculum and in the teeth.

On dead wood of deciduous trees. Type collected at Ferriday. La., Aug. 1, 1931. (U.S.F.P. Herb. 55624; Overholts Herb. 15254).

The gelatinized hyphae of the subiculum and their arrangement and compactness suggests rather the genus *Phlebia*, but the teeth are too well developed and too isolated to permit reference there. It is unfortunate that color records of the fresh plants were not obtained in the field, but the color on drying is distinctive.

FAMILY AGARICACEAE

Agaricus abruptibulbus Peck. Cantharellus cibarius Fr. Clitocybe decora Fr. on Taxodium. Flammula eccentrica Peck. Hypholoma incertum Peck. Lactarius lactifluus (L.) Fr. (La., Ark.); L. subvellereus Peck. Lentinus tigrinus (Bull.) Fr. Lepiota Morgani Peck; L. procera (Scop.) Fr. Marasmius iocephalus (Berk. & Curt.) Penn.; M. siccus (Batsch) Fr. Omphalia campanella (Batsch) Fr. Panus angustatus Berk. on Carya; P. laevis Berk. & Curt. on Liquidambar; P. rudis Fr. on Pinus and Quercus (La., Miss., Ark.); P. stypticus (Bull.) Fr. on Quercus. Pleurotus corticatus Fr. on Carya (Ark.); P. ostreatus (Jacq.) Fr. Schizophyllum commune Fr. on Carya, Diospyros, Gleditsia, Liquidambar (La., Ark.). Volvaria bombycina (Pers.) Fr. on Acer rubrum and Liquidambar.

Of the above species none were particularly abundant. Lentinus tigrinus was not collected but several wood rot isolations yielded cultures that produced typical sporophores of that species. Lepiota Morgani was fairly common in grassy woods and especially along grassy roadsides. Marasmius iocephalus was collected several times and is easily recognized

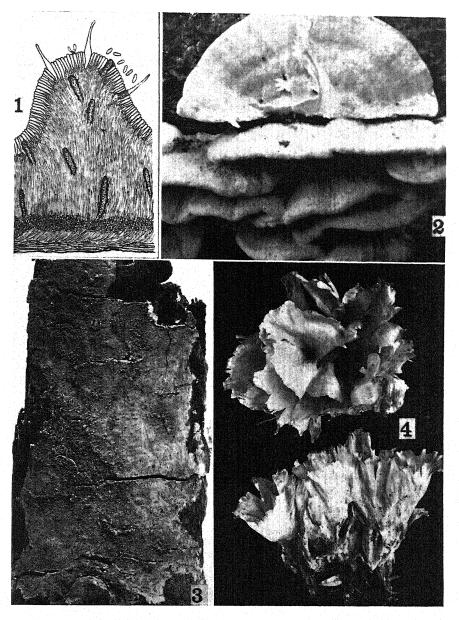


Fig. 1. Camera lucida drawing of section through a sporophore of $Odontia\ brunnescens$. Type collection. $\times 600$.

- Fig. 2. Photo of *Hydnum pulcherrimum*. Upper specimen showing hymenial surface. $\times \frac{1}{2}$.
 - Fig. 3. Photo of type material of Odontia brunnescens. $\times 2$.
 - Fig. 4. Photo of fresh specimens of Stereum pargamenum. ×1.

by its violaceous color. *Panus laevis* was found several times growing from wounded areas in living trees of Liquidambar. It is likely to be mistaken for a *Pleurotus* but the pileus and stem are both very hairy and the sporophore assumes a uniform yellow color on drying. *Volvaria bombycina* was found several times growing from knots in living trees.

FAMILY BOLETACEAE

Boletus chrysenteron (Bull.) Fr. Strobilomyces strobilaceus Berk.

FAMILY POLYPORACEAE

Daedalea ambigua Berk. on Carya, Celtis, Diospyros, Gleditsia, Quercus (La., Miss., Ark.); D. confragosa (Bolt.) Fr. on Liquidambar and Quercus; D. elegans (Spreng.) Fr. on Carya and Gleditsia; D. farinacea (Fr.) comb. nov. (Irpex farinaceus Fr.) on Quercus; D. unicolor (Bull.) Fr. on Celtis. Fomes applanatus (Pers.) Gill. on Populus deltoides; F. Calkinsii (Murr.) Sacc. & Sacc. on Quercus; F. conchatus (Pers.) Gill. on Fraxinus; F. densus Lloyd on Carya and Fraxinus; F. fraxineus on Fraxinus; F. geotropus Cooke on Acer, Liquidambar, Magnolia, Populus, Ulmus (La., Miss.); F. igniarius var. laevigatus (Fr.) Overh. (Poria laevigata Fr.) on Fagus, Gleditsia, Quercus; F. lobatus (Schw.) Cooke on Quercus (La., Miss.); F. marmoratus (Berk. & Curt.) Cooke on Carya, Celtis, Diospyros Gleditsia, Liquidambar, Quercus, Ulmus; F. Meliae (Underw.) Murr. on Fraxinus, Gleditsia (La., Ark.); F. rimosus Berk. on Robinia; F. tenuis Karst; F. torulosus on Fraxinus (Ark.). Lenzites betulina (L.) Fr. on Liquidambar, Quercus (La., Ark.); L. saepiaria (Wulf.) Fr. on Pinus (La. Miss., Ark.). Polyporus abietinus (Dicks.) Fr. on pine slash (La., Miss.); P. adustus (Willd.) Fr. on Celtis, Gleditsia, Liquidambar, Quercus (La., Miss., Ark.); P. anceps Peck on Pinus taeda (Miss.); P. arcularius (Batsch) Fr. on Gleditsia; P. biformis (Kl.) Berk. on Carya and Quercus (La., Ark.); P. cinnabarinus (Jacq.) Fr. on Quercus (La., Ark.); P. cristatus (Pers.) Fr. (Ark.); P. Curtisii Berk. on Carya, Gleditsia, Quercus (La., Miss., Ark.); P. cuticularis (Bull.) Fr. on Acer, Celtis, Quercus, Ulmus (La., Ark.); P. dichrous Fr. on Carya, Cephalanthus, Fraxinus, Quercus, Ulmus (La., Ark.); P. distortus (Schw.) Fr. on Carya, Quercus (La., Ark.); P. dryophilus Berk. on Quercus; P. fimbriatus Fr.; P. fissilis Berk. on Liquidambar and Quercus; P. focicolus Berk. & Curt. (La., Miss.); P. frondosus (Dicks.) Fr. on Quercus; P. galactinus Berk. on Liquidambar and Quercus; P. giganteus on Quercus; P. gilvus (Schw.) Fr. on Cephalanthus, Crataegus, Diospyros, Fagus, Liquidambar, Pinus, Quercus, Taxodium (La., Miss., Ark.); P. hirsutus (Wulf.) Fr. on Celtis, Nyssa, Populus; P. his pidus on Quercus (La., Miss., Ark.); P. hydnoides (Sw.) Fr. on Carya,

Gleditsia, Liquidambar, Ulmus; P. lucidus (Curt.) Fr. on Celtis, Diospyros, Liquidambar, Planera, Quercus (fig. 9); P. ludovicianus (Pat.) Sacc. & Trott. on Liquidambar and Quercus (La., Ark.); P. maximus (Mont.) Overh. on Ulmus; P. mutabilis Berk. & Curt. on Diospyros, Nyssa, Quercus (La., Ark.); P. nidulans Fr. on Carya; P. obtusus Berk. on Quercus; P. palustris Berk. & Curt. on Pinus (La., Miss.); P. pargamenus Fr. on Fagus and Liquidambar (La., Ark.); P. persicinus Berk. & Curt.; P. pinsitus Fr. on Fraxinus and Gleditsia (La., Ark.); P. porrectus (Murr.) Sacc. & Trott.; P. radiatus var. Cephalanthi n. var. on Cephalanthus occidentalis; P. rhipidium Berk. on Liquidambar and Quercus (La., Ark.); P. robiniophilus (Murr.) Lloyd on Celtis (Miss.); P. sanguineus (L.) Fr. on Liquidambar and Quercus; P. Schweinitzii Fr. on Pinus; P. sector (Ehr.) Fr. on Carya, Liquidambar, Quercus (La., Ark.); P. semipileatus Peck; P. Spraguei Berk. & Curt. on Fraxinus, Liquidambar, Quercus (La., Ark.); P. subectypus (Murr.) Lloyd on Liquidambar; P. submurinus on Populus, Fraxinus, Quercus; P. sulphureus var. cincinnatus Morg. on Quercus; P. supinus (Sw.) Fr. on Carya, Diospyros, Fraxinus, Gleditsia, Liquidambar, Quercus, Ulmus; P. tenuis (Sacc.) comb. nov. (Polystictus tenuis Sacc.) on Taxodium; P. versatilis (Berk.) comb. nov. (Trametes versatilis Berk.) on Taxodium; P. versicolor (L.) Fr. on Liquidambar; P. vinosus Berk. on Liquidambar; P. zonalis Berk. on Carya, Celtis, Liquidambar, Populus, Quercus (La., Ark.). Poria albocincta Cooke & Massee; P. ambigua Bres. on Celtis and Liquidambar; P. candidissima (Schw.) Cooke; P. eupora Karst. on Quercus; P. ferruginosa (Schrad.) Fr. on Liquidambar; P. flaccida sp. nov. on Carya, Liquidambar, Taxodium; P. inermis Ell. & Ev. on Ilex; P. Langloisiana Murr. on Liquidambar; P. Langloisii Murr. on Fraxinus and Quercus (La., Ark.); P. medulla-panis (Pers.) Cooke; P. nigrescens Bres.; P. punctata Fr. on Carpinus and Fraxinus (La., Ark.); P. undata Pers. on Fraxinus; P. versipora Pers. on Ilex and Quercus (La., Ark.). Solenia candida Pers. on Taxodium. Trametes cubensis (Mont.) Sacc.; T. malicola Berk. & Curt.; T. rigida Berk. & Mont. on Fraxinus and Carya; T. sepium Berk.

The following species of Polyporaceae are deserving of further notice here:

Polyporus fimbriatus has not previously been reported from the North American mainland. Its relationships have been confused due to the fact that the hymenium develops very differently at different times, so that the species has been classed in both Thelephora and Hydnum, and previous southern collections have been referred as forms of the thin and variable Polyporus tenuis or its near relatives. It grows from buried rotted wood in large soft white tough imbricate clusters like Stereum pargamenum,

and in fact my photo of that species (fig. 4) represents it very well from the upper surface view. It occurred several times in late July and early August after abundant rains.

Polyporus fissilis Berk. Soft and watery, white throughout, cartilaginous within or forming mucilaginous or soapy masses in the crevices near the fruiting bodies, drying yellowish; context strongly zonate; pores medium-sized, the pore surface slightly lavender (figs. 5, 12, 13).

On living Liquidambar and on living Quercus, especially Q. nigra and Q. Phellos. Common in central and northern Louisiana and in adjacent Mississippi and Arkansas. Produces hollows in butts and lower trunks of living trees, preceded by a soft, ropy, general, cinnamon-colored or whitish decay of the heartwood, with persistent medullary rays. One of the most destructive heart-rotting fungi of the region, the decay either a butt rot or a trunk rot. Occasionally on logs down two or three years. Sporophores are frequently abortive, producing no tubes. The species is widely distributed in the eastern United States but northward it is very sporadic in appearance and has never been regarded as of any importance in Forest Pathology. Although observed many times in some stage of fruiting, no sporophores were seen that were not within reach from the ground, indicating that it is most frequently to be found as a butt-rot.

Polyporus ludovicianus (Pat.) Sacc. & Trott. This species has received little attention from mycologists. It was originally described from Louisiana. Lloyd considered it to be a form of P. cuticularis. Probably less than a dozen collections were known prior to 1931. We found it to be a rather common species and several collections were made. It grows in imbricate clusters after the manner of P. sulphureus, the clusters sometimes as much as 45 cm. broad. The entire sporophore is brown or rusty-ochraceous in color with thin applanate pilei, zoned and matted-tomentose on the upper surface. The spores are like those of P. cuticularis, brown in color, $5-6\times$

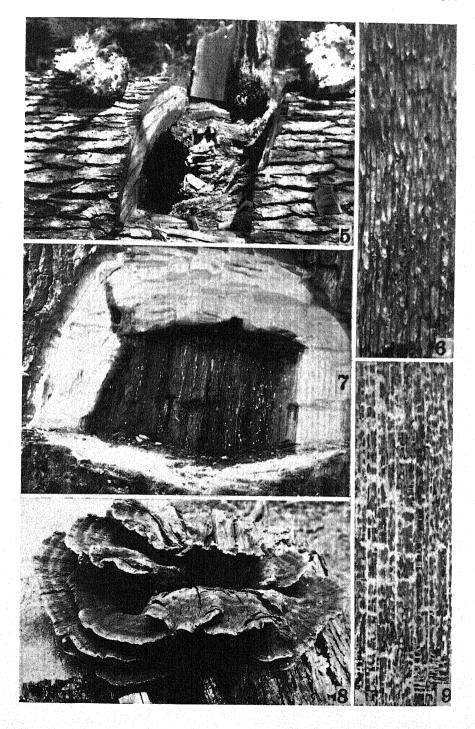
Fig. 5. Photo of cut in log of *Liquidambar styraciftua* showing hollow and rot produced by *Polyporus fissilis*, and at right and left masses of white fungous material of soap-like consistency taken from inside log at this point. Cut made at 19 ft. above stump. Greatly reduced.

Fig. 6. Showing advanced stage of rot in Liquidambar, as seen in tangential section view, caused by *Polyporus ludovicianus*. $\times 1$.

Fig. 7. Heart rot in living Quercus, caused by Polyporus sulphureus. Greatly reduced.

Fig. 8. Imbricate sporophore mass of *Polyporus ludovicianus* growing on top of Quercus stump at Oak Grove, La. $\times \frac{1}{4}$.

Fig. 9. Photo of heart rot in living Quercus, caused by Polyporus lucidus. ×1.



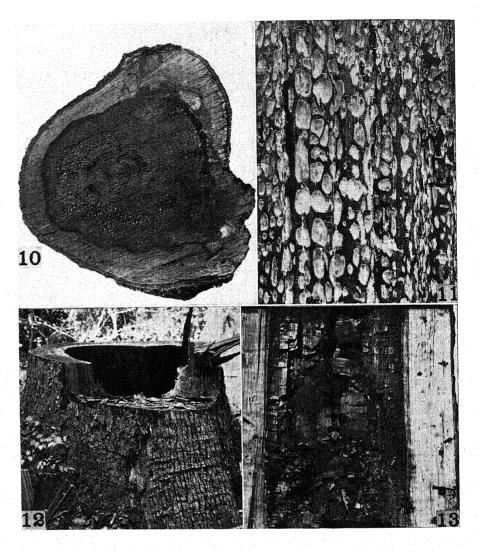


Fig. 10. Photo of cross section of log of Quercus with advanced stage of decay by *Polyporus hispidus*. $\times \frac{1}{4}$.

Fig. 11. Photo of large pocket rot in Quercus, probably produced by *Polyporus* zonalis. ×1.

Fig. 12. Photo of stump of Liquidambar showing large hollow produced by *Polyporus fissilis*. This stump is of the same tree shown in Fig. 5. Greatly reduced.

Fig. 13. Advanced stage of rot of heartwood in Quercus, caused by *Polyporus fissilis*. The persistent medullary rays are characteristic of the rot on this host. $\times \frac{1}{3}$.

 $3.5-4\,\mu$. Setae are not present and in this character it differs from the last-named species. It fruits only at the bases of living trees or quite as often on or about stumps of Liquidambar and Quercus. It produces a conspicuous speckled pocket-rot of the heartwood and seems to be one of the most destructive heart-rot organisms of the region. The pockets produced resemble those by Stereum frustulosum and S. subpileatum. The species proves to be rather widely distributed in the southern states, and collections are now known from South Carolina, Georgia, Alabama, Louisiana, and Texas (figs. 6, 8).

Polyporus persicinus Berk. & Curt. This species was originally described from South Carolina and has been collected but three or four times. Type fragments are said to be found at Kew and were studied by Murrill who reported that the description does not seem to apply to the type specimens and our present conception of the species is based on the type specimens rather than on the description. Coker twice collected the species at Chapel Hill, North Carolina, in this sense, and his specimens are at New York. I collected it once near Eudora, Ark. The species has considerable resemblance to the well developed centrally stipitate form of P. distortus. It grows on the ground though is probably attached to buried wood. The pilei are 10–25 cm. diameter, buffy-brown to pinkish brown when fresh but becoming sordid refescent-brown in age or on drying and the context of fresh specimens changes to a brownish-flesh-color where exposed, and is very friable and pale-brown on drying.

Polyporus radiatus var. Cephalanthi n. var. Sporophore practically resupinate, with only a tumid margin, yellowish-brown, tough; context brown; pore surface dark brown, the tubes 1-3 mm. long, their mouths averaging 4 to 5 per mm.; setae present, many with curved tips; spores nearly or quite hyaline, $4-4.5\times3.5-4\mu$.

On dead standing Cephalanthus occidentalis. Common in northern and central Louisiana and at Eudora, Ark. Observed at many different stations. Never found with more than a suggestion of a pileus, which, together with the unusual and restricted habitat and the hooked setae almost make it worthy of specific recognition, especially since P. radiatus is not known to occur in its pileate form so far southward.

Polyphorus sulphureus var. cincinnatus Morgan. Forming imbricate or rosette-like clusters 10–50 cm. broad, the pilei salmon-colored above, white below, fleshy at first, finally brittle; otherwise it resembles the species except that it always occurs at the bases or on the roots of living trees of Quercus, apparently from the ground, but in reality producing a pseudo-sclerotium, often of considerable length leading to infested roots. This

pseudo-sclerotium exudes milky drops where broken. The present form is described in more detail by Rosen (Mycologia 19: 191. 1927) August. Collected but once, at Oak Grove, La. Produces a carbonizing cubical rot of the heartwood (fig. 7). When heartwood heavily infested by the mycelium of this fungus is cut into, drops of a milky fluid collect on the cut surface of the wood.

Poria flaccida n. sp. Resupinate, annual, entirely white or drying cream-colored, soft and watery when fresh, drying rather soft; margin white, myceliod and cobwebby over the adjacent bark; subiculum very thin and delicate, cottony, white; pore surface even, the tubes up to 1 mm. long, their mouths angular, thin-walled, entire, averaging 3 to 4 per mm.; spores almost exactly globose, smooth, hyaline, $4-4.5\times4\mu$; cystidia none; basidia $4-5\mu$ diameter; hyphae flexuous, simple or sparingly branched, thin-walled and flaccid, with frequent cross walls but no clamps, diameter $2.4-3\mu$ in trama, $3-4\mu$ in subiculum.

On old logs of Carya, Liquidambar, and Taxodium. Louisiana. Type collected near Kilbourne, La., Aug. 14, 1931, on Carya log (U.S.D.A. For. Path. Herb. 50356; Overholts Herb. 14073); also collected near Ferriday, La. This species is a close relative of *P. ambigua* Bres. but differs in the globose spores and the somewhat smaller hyphae.

A genetic analysis of the inheritance of fragrance of gladiolus.

FORMAN T. MCLEAN

This study was undertaken for the purpose of developing and intensifying fragrance in the gladiolus. Two of the ten or more fragrant species of the genus Gladiolus—i.e. the highly variable G. tristis and equally variable G. recurvus, were intercrossed and records were kept of their progeny in the first and second generations and in a back-cross, to learn the mechanism of inheritance of fragrance in them. In all 2,200 individuals were studied, comprising 194 crosses. Fairly complete descriptions were made of these, and this mass of data was tabulated under twenty-five characters, two of which are of fragrance; a night fragrance derived from G. tristis and a violet-like daytime fragrance from G. recurvus. The clones of the two species used were apparently homozygous for the characters for fragrance, but for many of the other characters they were evidently heterozygous. This was to be expected, since the wild forms of both species vary greatly in color and markings, but have characteristic fragrance, and leaf and sheath characters.

Through the liberal cooperation of the officers and personnel of the Works Progress Administration, whose assistance it is a pleasure to acknowledge, this material was tabulated and compared in detail. The statistics were handled by Mr. Erwin Jarmel, who did excellent work on it. Only one phase is treated here.

The results clearly indicate that the two primary types of fragrance are inherited differently. The lily-like night fragrance of *G. tristis* is apparently recessive to the absence of it, and dependent on two factors for its transmission, one of which must be homozygous for its expression, but the other heterozygous. The violet-like recurvus fragrance is dominant and appears to require two factors, both of which may be heterozygous. Recurvus fragrance is also epistatic to tristis fragrance in certain combinations. Of the twenty-three other characteristics recorded, only four have evident relationships to fragrance; two to tristis fragrance, one to recurvus, and one to both. Considering the heterozygosity of these other factors, no linkage groups can be postulated here to further substantiate or tend to disprove the two-factor hypothesis for the inheritance of each type of fragrance. But the evidence for it seems sufficient in itself.

Two new types of fragrance, each more pronounced than the primary species types, were found in the hybrids. Further studies of these to learn their manner of inheritance, and studies of the transmission of fragrance to crosses of these species hybrids with the garden varieties of gladiolus are in progress. Both show promise.

REVIEW OF LITERATURE

There has been comparatively little breeding work to develop or intensify scent in flowers, and most of the workers have left no record of the inheritance of scent, except in very broad generalizations. Hampton¹ summarizes these observations. A preliminary report of the present work with gladioli was printed in 1933.² As already noted there, this was not the first attempt to produce fragrant gladioli. Dean Wm. Herbert reported the same cross in 1818 in a letter to the Royal Horticultural Society, London³ and he subsequently named his hybrids Gladiolus fragrans. But that was long before the days of modern genetics, and there is no evidence that he carried the experiment beyond the first generation.

One reason for the lack of information on inheritance of fragrance is the inexactitude of the standards for odors and the mixed character of most of the natural ones, which are usually made up of several odors blended together. Hampton (loc. cit.) classifies odors of plants into ten groupings: (1) Indoloid or foetid, as in *Stapelia* and other carrion flowers; (2) Animoid or stale, as in hawthorn blossoms; (3) Heavy and sweet, as in jasmine; (4) Aromatic or sweet and spicy, as in clove carnation, night scented tobacco, etc.; (5) Violet or orris; (6) Rose; (7) Lemon, as in oranges and magnolias; (8) Fruit scented, as in *Philadelphus microphyllus*; (9) Animal and unpleasant, as in the lizard orchid; (10) Musk and honey, as in the musk plant and musk orchid.

Of these ten groupings, the fragrances dealt with here are:

- I—Gladiolus tristis scent, a night scent belonging to class (4) Aromatic, possibly combined with some of class (7) Lemon.
- II—The "Violet" scent of *Gladiolus recurvus* which is the strongest early in the morning and persists during the day, obviously belongs to class (5) Violet, possibly with other modifying elements in it.

Derived from these are:

III—"Lemon" scent, a daytime scent found in some of the hybrids, and:IV—"Pungent," another daytime scent, occurring principally among the F₂ and later crosses.

Each of these four scents is clearly distinguishable, both by its time of occurrence, day or night, and by its dominant odor component, but it is quite probable that each is not a simple odor, rather a combination of

- ¹ Hampton, F. A. "Flower scent," pp. 104-106. London, 1925.
- ² McLean, Forman T. "The inheritance of fragrance in *Gladiolus* species crosses," Jour. N. Y. Bot. Garden 34: 73–80. 1933.
- ³ Herbert, Wm. "Instructions for the treatment of Amaryllis longifolia as a hardy aquatic, with some observations on the production of hybrid plants, etc." Trans. Hort. Soc. London, 3: 187–196. 1820.

two or more. For each plant recorded, the quality of the fragrance is set down according to the above groupings, and its intensity, whether faint, medium or strong. Observed differences in intensity are not treated in the present analysis; the personal element enters too strongly into the perception of scent, as recently proven by the studies of Blakeslee⁴ All of the observations of fragrance here reported were made by the author, with the corroboration of two co-workers, Miss Helene Lunt and Mrs. Harry A. Jennison, whose perceptions of scent were about the same as his. If the work had been done by a number of people, differing in the keenness of their perceptions, such consistent results would not have been possible; a person with keener sense of smell might have detected scent where the author did not, as actually happened in the case of a gladiolus scent not discussed here. On the other hand, many visitors proved to be insensitive to one or the other of the odors treated in this paper. So the results reported may be regarded as simply one man's consistent observations.

RESULTS

This study was begun at the Rhode Island Agricultural Experiment Station in 1925, and continued at the New York Botanical Garden from 1928 to 1937. The Boyce Thompson Institute for Plant Research, through the kindness of Dr. Crocker, worked out for me the pregermination cold treatment necessary for the germination of the seeds of these small gladiolus species and hybrids, the chemical treatments to break the dormancy of gladiolus corms, and the effect of supplemental light on blooming time.

The results here reported were based principally on hybrids derived from one clon each of *Gladiolus tristis* and of *Gladiolus recurvus*. A second clon of *G. recurvus* was used for the production of some first generation hybrids, and these are treated separately for comparison.

The G. tristis used is designated Tristis II, and was obtained from C. G. Van Tubergen & Co. as G. tristis concolor. The flowers are clear greenish cream, large for the species, and only two to four on each spike. The general characteristics of this clon, which was used as the seed parent of all of the F_1 hybrids here treated, are given in detail in the discussion after table 1.

The G. recurvus clon used principally in this study is called Recurvus Bronze, and was obtained from A. J. Kruijff, of South Africa, who called it the best and strongest growing form of the species. In greenhouse culture

⁴ Blakeslee, Albert F. "Demonstration of differences between people in the sense of smell," Scientific Monthly 41: 72-84. July, 1935.

here it is a weak grower, like all of *G. recurvus*, with rather flatter greyish leaves than the type, and light purplish bronze flowers instead of the typical violet or cream.

In series #55 of the first generation hybrids, a second clon of G. recurvus was used, called Recurvus Violet Purple. This was typical of the

species.

In table 1, the distribution of the twenty-five recorded characteristics, including those for fragrance, are compared in the first generation hybrids, in series #55 (columns 2 and 3), in which Recurvus Violet Purple was the pollen parent; in series #60 (columns 4 and 5), in which Recurvus Bronze was used; in the second generation (columns 6 and 7), derived from series #60; and a back-cross in which F_1 #60 was recrossed with Tristis II. In the discussion of the results as given in the table, the characteristics of the species clons used as parents are also taken up.

The columns headed "N" give the number of individuals in each category. Observations are incomplete for certain characters of a few individuals, so that the total records on many characters do not add up to the total number of individuals studied, but the number of such omissions is believed to be not great enough to seriously affect the percentage distributions.

TABLE 1

Inheritance of twenty-five observed characters in first generation, second generation and back-cross of

Gladiolus tristis and Gladiolus recurvus

No. of Records		FIRST FIRST GENERATION F1 #55 F1 #60 191 192		GENERATION		SECOND GENERATION F ₂ #60		BACK-CROSS TRISTIS II X F ₁ #60	
				92	362		2	84	
	N	%	N	%	N	%	N	%	
CHARACTER									
0. No. of Flowers									
One	40	21.5	12	6.8	- 88	26.4	65	22.9	
Two	89	47.9	75	42.6	168	50.5	156	54.9	
Three or More	57	30.6	89	50.6	77	23.1	63	22.2	
1. HEIGHT/LENGTH							1.		
Plus	10	5.3	45	27.3	64	17.8	97	33.9	
Minus	180	94.7	120	72.7	296	82.2	189	66.1	
2. Flower Size					100		427.0		
½" to 1"	5	2.8	19	10.9	50	14.6	0	0	
$1\frac{1}{8}''$ to $1\frac{5}{8}''$	75	43.1	84	48.0	196	57.1	32	12.0	
1 ³ / ₄ " to 2 ¹ / ₄ "	89	51.3	72	41.1	91	26.5	184	68.9	
$2\frac{3}{8}''$ to $2\frac{7}{8}''$	5	2.8	0	0	6	1.8	51	19.1	
Statistical Average	1	.76	1	.62	1	.54	2	.14	
P. E. Average		.02		.05		.01		.01	

TABLE 1-Continued

	TABLE	1—Continu	ed.					
	GENER. F1		FIRS GENERA F1		SECO: GENERA F ₂	1	BACK-CI TRISTIS F.	
No. of Records	19		199	,	362	,	284	
	N IS	%	N 19.	%	N	%	N 255	%
Character								
3. Color of Flower				dis-		· ·		
Creamy	62	32.4	117	61.6	117	32.3	121	42.3
Creamy White	113	59.2	68	35.8	147	40.6	125	43.7
All Others	16	8.4	5	2.6	98	27.1	40	14.0
4. Shape of Flower					1123			06.7
Open	121	63.7	62	33.9	115	32.0	248	86.7
Intermediate	7	3.7	24	13.1	39	10.8	17	6.0
Bell	62	32.6	97	53.0	206	57.2	21	7.3
5. Tube Length								0.5
$\frac{1}{2}''$ to 1"	40	30.8	29	38.7	104	36.6	15	8.5
$1_8^{1}''$ to $1_2^{1}''$	81	62.3	45	60.0	168	59.2	76	42.9
15" to 2"	9	6.9	1	1.3	12	4.2	83	46.9
$2\frac{1}{8}''$ to $2\frac{5}{8}''$	0	0	0	0	0	0	3	1.7
Statistical Average		29	1.		1.			60
P. E. Average		02		04	•	01	•	01
6. Tube Shape						13.4	100	60.9
Curved	15	39.2	50	64.9	122	43.6	109	39.1
Straight	79	60.8	27	35.1	158	56.4	70	39.1
7. SEGMENT TIP			4.00		24.5	07.0	283	99.3
Pointed	169	88.5	130	88.7	317	87.8	200	.7
Blunt	22	11.5	15	10.3	44	12.2	2	
8. Segment Width		40 5	4.6	24.0	101	28.2	165	58.3
Narrow	26	13.7	46	34.8	101	21.2	43	15.2
Intermediate	9	4.7	22	16.7	76 181	50.6	75	26.5
Wide	155	81.6	64	48.5	181	50.0	13	20.0
9. Petal Texture		#0 4	00		206	57.4	164	57.7
Wavy	112	59.3	99	61.5	153	42.6	120	42.3
Plain	77	40.7	62	38.5	155	42.0	120	74.0
10. FLOWER COLOR GRAINING	424	70.0	01	49.7	171	47.2	15	6.0
Plus	134	70.9	91	50.3	191	52.8	234	94.0
Minus	55	29.1	92	30.3	191	32.0	204	
11. Flower Color Blotch	454	04.6	119	62.0	258	71.3	209	74.
Plus	174	91.6	1	38.0	104	28.7	73	25.
Minus	16	8.4	73	38.0	104	20.1	13	20.
12. FLOWER LINES TO TIP	4.50		1.12	70 1	234	64.8	146	51.
Plus	150	78.9	143	78.1 21.9	127	35.2	139	48.
Minus	40	21.1	40	21.9	121	00.4	109	10.
13. THROAT LINES	100		100	50.8	225	62.3	251	88.
Plus	122					37.7	34	11.
Minus	67	35.4	64	49.2	130	31.1	04	
14. Throat Dots	ر د مورد	00 =	1 77	EO F	205	56.8	91	32.
Plus	171			58.5 41.5				68.
Minus	18	9.5	54	41.5	130	+3.2	1 153	

TABLE 1-Continued

	TABLE 1	-Continu	ea .					
	FIRS GENERA F1		FIRS GENERA F1	1	SECO: GENERA F ₂		BACK-C TRISTIS F ₁	
			400	. 1	365	2	284	
No. of Records	191		192 N	%	N 002	%	N	%
	N .	<u></u> -						
CHARACTER								
15/16. Types of Fragrance		2.0	7	3.7	135	37.3	111	39.1
Non-fragrant	4		182	94.8	188	51.9	53	18.7
Recurvus Scented	185	97.0	102	74.0	2	.5	2	.7
Lemon Scented					18	5.0		
Pungent Scented				.5	6	1.7	90	31.7
Tristis Scented	2	1.0	1 2	1.0	8	2.2	17	6.0
Recurvus and Tristis			Z	1.0	3	.8	3	1.0
Tristis and Lemon					2	.6	8	2.8
Tristis—Day and Night		1			_			
17. Anther Color			4.00	80.3	215	59.7	168	59.2
Colored—Plus	183	96.3	139		145	40.3	116	40.8
Pale—Minus	7	3.7	34	19.7	143	10.0		
18. PISTIL COLOR					48	14.8	28	9.9
Colored—Plus	130	85.5	5	3.2	277	85.2	255	90.1
Pale—Minus	22	14.5	153	96.8	211	00.2	200	, , , ,
19. PISTIL LENGTH		* -			0.7	35.8	76	54.3
Plus Anthers	38	43.2	11	26.2	87	46.1	53	37.8
Equal Anthers	41	46.6	26	61.9	112	18.1	11	7.9
Minus Anthers	9	10.2	5	11.9	44	10.1	111	
20. Leaf Number					265	73.4	186	65.5
One	36	61.0	129	73.3	265	25.8	98	34.5
Two	23	39.0	45	25.6	93	25.8	90	31.0
Three or more			2	1.1	3	.0		
21. LEAF SECTION			1	4.		44.4	235	82.5
Cross—Plus	30	15.8	18	9.8	100	14.4	50	17.5
Intermediate	147	77.4	152	83.6	1	70.1	30	17.0
Flat—Minus	13	6.8	12	6.6	56	15.5		
22. LEAF COLOR						04.4	71	25.1
Grevish-Green	181	94.8	158	96.3		91.1	1	74.9
Yellowish-Green	10	5.2	6	3.7	32	8.9	212	74.3
23. LEAF SHEATH COLOR							150	56.
Brown	169	89.4	150	89.8		77.4	1	35.
Intermediate	15	7.9	14	8.4		17.5		
Green	5	2.7	3	1.8	3 18	5.1	21	7.
24. Leaf Sheath Dots								
Plus	190	99.5	5 164	98.	1			46.
Minus	1		5 3	1.	8 110	31.5	5 149	53.
TVIIIUS							- 	

Of the twenty-five characters treated in table 1, most of them appear to be either heterozygous in the parents of the plants studied, or so irregular in their distribution that they do not indicate any definite trend. The most promising characters are those for fragrance, which show consistent and clear-cut results. These are analyzed more fully in table 2.

The parent of series #60, Recurvus Bronze, appeared to be heterozygous for character 4, shape of flower; character 8, segment width, narrow and intermediate being opposed to wide; character 10, flower color graining; character 13, throat lines; and character 14, throat dots. In each of these instances, the parent of series #55, the more typical Recurvus Violet Purple, seems to be more homozygous, judging by the F₁ hybrids studied.

For characters 17, 21, 22, 23 and 24, the results in all of the different groups appear much more consistent. Characters 23 and 24 show distributions such as would point to simple dominance of one factor for each.

Taking up the characters a little more fully:

- 0. The two parent forms of Recurvus and Tristis II, each have two to four flowers per spike, and the hybrids average two flowers each.
- 1. The ratio of height of flower stalk to length of longest leaf is consistently negative, and follows the tendency of *G. recurvus*, which is short stalked, while *G. tristis* is long.
- 2. Tristis II is large flowered, averaging $2\frac{1}{2}$ inches in diameter, while Recurvus averages $\frac{3}{4}$ to 1 inch. The hybrids are intermediate.
- 3. The flower color is predominantly creamy white, leaning toward the color of *G. tristis*.
- 4. Tristis II is distinctly a wide open flower, while Recurvus is more bell shaped. The hybrids are again intermediate.
- 5. A long perianth tube, 2 inches long, is a character of Tristis II, while Recurvus Bronze and Recurvus Violet Purple both average about \(^3_4\) inch. The hybrids are intermediate.
- 6. The curvature of the perianth tube is highly variable, and shows no clear inherited tendency, except that Tristis is curved.
- 7. The pointed segments of G. tristis are strongly epistatic over the blunt segments of Recurvus.
- 8. Wide segments, more than half as wide as long, are characteristic of Recurvus in contrast with the narrower segments of Tristis II. If narrow and intermediate are contrasted with wide, and Recurvus Bronze is assumed to be heterozygous for one of two dominant factors for wide, Tristis II and Recurvus Violet Purple being homozygous for wide and for narrow segments respectively, the distribution found closely approximates what would be expected, which is 100% wide in F₁ #55, 50% wide in F₁ and in F₂ #60, and 75% intermediate and narrow in the back-cross.

9. The perianth of Tristis II is plain, not wavy or ruffled, while that of Recurvus is inclined to be wavy, and this tendency slightly

predominates in the hybrids.

10. Tristis II has a clear color, without markings. Recurvus is usually grained and stippled with darker color over the cream or creamy white ground color. In this case, both of the Recurvus parent forms appear to be heterozygous for the character for graining, Recurvus Bronze the more so.

11. Dark blotches on the three upper segments are characteristic but not invariable in *G. tristis*. Tristis II lacks blotches, and Recurvus in all its forms has narrow center lines or none. Despite

this, blotches appear to preponderate in all groups.

12. Dark central lines to the tips of the segments of the flowers are characteristic of Recurvus Violet Purple, and most Recurvus, but do not occur in Tristis II. The tendency for these lines is evidently somewhat heterozygous in both forms of Recurvus. The back-cross shows a typical 1:1 ratio, possibly indicating this character to be a simple dominant.

13. The lower lip of Tristis II has greenish central lines in the throat, while Recurvus does not. No definite tendency can be detected

in this case.

- 14. Dark dots on the lower lip at the throat characterize most forms of Recurvus; Tristis II lacks dots. Recurvus Bronze is evidently heterozygous for this character, which, from the distribution shown in table 1, and the linkages to characters for fragrance, discussed later, is assumed to depend on two supplementary dominant factors.
- 15 & 16. These characters refer to fragrance. Under 15 are recorded "day-scented" flowers. These include (1) violet scented flowers, with a fragrance like Recurvus by day, which are strongly dominant in the first generation, but do not appear in the F₂ and back-cross in the proportions expected for a simple dominant factor; (2) Lemon scented, appearing among the F₂ and back-cross, both alone and in combination with Tristis scent at night. This is evidently a derived scent, not found in either of the wild forms used, and is too scantily represented here to permit analysis of its inheritance. (3) Pungent scent, mildly resembling that of a carnation, is another derived scent, and found to the number of 18 (5%), only in the F₂, neither in F₁ nor back-cross. This would seem to argue for an affiliation with Recurvus scent. Under 16

are recorded "night-scented" flowers, which have the strong lily-like scent of G. tristis either alone or combined with other scents by day. This character is distinctly recessive in the F1, and less represented in the F_2 and back-cross than would be expected of a simple recessive allelomorph to Recurvus scent. The proportions of these scents among the different groups, and the large number of non-fragrant hybrids in the F2 and back-cross, though derived from scented parents and grandparents, exclude the possibility of these traits being inherited either as allelomorphs or as simple independent characters. In the next section an hypothesis is presented which successfully accounts for all of the findings. Discussion of this will be deferred until that is taken up.

17. Dark-colored anthers are characteristic of Recurvus, and while Tristis II had pale anthers, dark color in them is frequent in other forms of G. tristis. Anther color is dominant in the F1, but only to the extent of 80% in the F1 #60. If we may assume both Recurvus Bronze and Tristis II to be heterozygous for a dominant factor for anther color, this would quite reasonably account for the findings, except for the absence of it in Tristis II.

18. Recurvus Violet Purple had a violet colored pistil, and this character was evidently dominant in the F1. Recurvus Bronze and Tristis II both had pale pistils.

19. Tristis II has the pistil longer than the anthers, and Recurvus

has it shorter. The hybrids are intermediate.

20. The number of fully developed leaves per plant is normally two in Tristis II, but one in Recurvus; and the one-leaf predominates in the hybrids.

21. The leaf cross-section is cruciate in Tristis II, but flat in Recurvus. The hybrids are quite definitely intermediate, except the back-cross, which leans strongly toward the Tristis form.

- 22. Tristis II has a normal bright yellowish-green leaf color while Recurvus has greyish-green, which is dominant in the F1, just as strongly represented in the F_2 , but only 25% are greyish-green in the back-cross. The genetic explanation of this type of distribution is not clear.
- 23. The color of the leaf sheath is brown in both Tristis II and both clons of Recurvus, so would be expected to dominate the hy-
- 24. The leaf sheath of G. recurvus is characteristically dotted with pale greyish dots on a basic green or brown color. This dotting

is apparently a simple dominant over the uniform sheath color of Tristis II, the two F_1 series being dotted 98 and $99\frac{1}{2}\%$ respectively; $68\frac{1}{2}\%$ dotted in the F_2 , approaching a 3:1 ratio; and 47% dotted in the back-cross, nearly a 1:1 ratio, as expected for a one-factor dominant. None of the other characters show such a simple relationship. But the characters for fragrance show interesting trends, which are next considered in detail.

INHERITANCE OF FRAGRANCE

If it is assumed that two supplementary factors, designated for convenience R and S, either or both of which may be heterozygous, are necessary to develop recurvus fragrance; that two other supplementary factors, located on different chromosomes and designated T and U, are both necessary, one heterozygous and the other homozygous, to develop tristis fragrance; and that recurvus fragrance is epistatic to tristis fragrance in certain combinations; and further that lemon and pungent are combinations containing tristis fragrance factors; then this hypothesis will account within 2 per cent of error, in all except the first generation, for all of the results given in table 2, which compares the actual inheritance distribution with the computed values based on these assumptions.

Tristis II would then have the genetic formula rrssTTUU, and Recurvus the formula RRSSttuu, with respect to fragrance alone. The small letters, r,s,t and u represent the non-fragrant allelomorphic factors to the fragrance factors, R,S,T and U, respectively. In the hybrids, all having at least one R and one S will also have recurvus fragrance; and those having one T with two U's will have tristis fragrance. But it is further assumed that recurvus fragrance is epistatic to tristis fragrance to such a degree that in the presence of both R and S, homozygous T as well as homozygous U is necessary to bring out both recurvus and tristis fragrances in one individual. Thus RrSsTTUU, or RRSsTTUU, or RRSSTTUU would carry both recurvus fragrance by day and tristis fragrance at night. But RrSsTtUU would show only recurvus fragrance, despite the fact that individuals with TtUU without R and S together would have tristis fragrance, as would all those with TTUU, regardless of R and S. The computed values in Table II are based on this hypothesis.

The possibility that the ten percentage values, for recurvus scent in two groups of first generation hybrids, of non-fragrant, recurvus scented, recurvus and tristis scented, and of tristis scent with other combinations, would all except two fall within two per cent of the expected percentages, and that even these divergent values would not deviate more than 4 per cent from those expected, without the hypothesis being true, seems very

TABLE 2

Comparison of inheritance of recurvus and tristis fragrance with expected values based on two factors for each

	FIRST GENERATION		FIRST GENERATION		SECOND GENERATION		BACK-CROSS	
	Recu	s II× irvus,	F _{1 7} Tristis Recu	s II× rvus,	F_{27} $F_{1} \# G_{17}$	50×	Tristis	
No. of Plants recorded Column A—Actual %		P. 91	bro 19		36	52	28	34
Column C—Computed %	A	C	A	С	A	C	A	С
Non-fragrant Recurvus scented	2 97	0 100	3.7 94.8	0 100	37.3 51.9	$35\frac{1}{2}$ $52\frac{3}{4}$	39.1 18.7	$37\frac{1}{2}$ $18\frac{3}{4}$
3. Recurvus and Tristis4. Tristis scented	0 1	0	1.0	0	2.2 1.7 .5	3½ *	6.0	6 1 *
5. Lemon scented 6. Pungent scented	0	0 0 0	0 0	0	5.0	*	0	*
7. Lmon and Tristis8. Tristis, day and night	0	0	0	0	.8	*	2.8	*
* Total, Tristis, Lemon and Pungent combined					*8.6	*81/4	*36.2	*37½

^{*} Note: These totals are of items 4 to 8 inclusive; Tristis, Lemon, Pungent and combinations of these.

remote. With from two hundred to four hundred individuals recorded in each group, a deviation of 2 per cent from the calculated values is about the normal variability. There seems, therefore, to be no need to assume a more complex or a very different hypothesis from the one proposed to account for the inheritance of the two primary types of fragrance. This explanation does not account for the lemon and pungent scents, except to place them with the tristis group.

RELATION OF OTHER CHARACTERS TO FRAGRANCE

To see if there were any indications of linkage of any of the twenty-three other characters to fragrance, all of the data of second generation and later hybrids, (excluding the first back-cross to tristis, Group #152) comprising in all 852 individuals were tabulated with respect to fragrance, and presence or absence of each of the twenty-three other characters, and the material was summarized, showing percentage of the plants possessing a given type of fragrance which also possess a given other character. Then the coefficient of contigency⁵ for each of the most strongly probable re-

⁵ See, Davenport, C. B. and Ekas, M. P. Statistical Methods, 4th Revised Edition, John Wiley & Sons, 1936.

lations was worked out. The detailed results are not presented here, as they did not prove significant for the present study, except that nine characters numbers 4,6,8,10,12,14,21,22 and 24, (see discussion of table 1 for detailed description of these) showed a strong coefficient of contingency, exceeding .100 in value, for a relationship of the other character to tristis or recurvus fragrance. It is noteworthy that in each of these instances, in every case the porportion of individuals with a given fragrance which also have the character is high, sixty to ninety per cent (see table 3), but the converse of this is not true—that is, of the total number possessing the apparently linked character, the proportion also possessing the fragrance is always less than fifty per cent. To test the significance of these apparent relationships, and to find whether they may represent true linkages between the other characters and fragrance, the 852 indivuals were subdivided into six inheritance groups, designated studies 1 to 6 respectively, as follows:

Study#1 N—362 Second Generation Tristis II \times Recurvus Bronze

Study #2 N-173 Second Generation of #152 (Back-cross to Tristis)

Study #3 N-74 Second × Third Generation of #152

Study #4 N—54 Second Back-cross to Tristis (Tristis × #152)

Study #5 N-62 Cross between First and Second generation

Study #6 N—127 Cross between First and Second Generation of Backcross #152

A portion of this material and a small amount of scattered supplemental data was then lumped into two groups, one consisting of individuals with equal contibutions of *G. tristis* and *G. recurvus* to their pedigrees, and a second group in which all of the individuals have a preponderance of *G. tristis* in their pedigree, as follows:

Group I. Revised study #1 comprises 362 F_2 #60.

Individuals and study #5 comprises 62 individuals of a cross F_1 #55 \times F_2 #60, making a total of 424 individuals.

Group II. Derivatives of the Tristis back-cross #152 crossed with each other and with other groups, consists of 374 individuals.

Group I is thus equally G. tristis and G. recurvus in inheritance, while Group II is $\frac{5}{8}$ or more G. tristis and shows strong dominance of G. tristis characters.

Any apparent linkage of one character with another may be influenced by dominance of that character, so that two dominant characters may appear to be linked with each other when they really are not. In such instances, if the linkage does not persist in back-crosses in which either or both characters are relatively less frequent, then the apparent linkage is believed not to be significant.

The results of these groupings are given in table 3. In column 1 are

given the characters by number, as described earlier, column 2 gives a statement of the premise for a linkage, columns 3 and 4 give data for the total of 852 cases; in column 3 the norm, that is the percentage of the total group possessing the given character and in column 4 the percentage of the scented individuals also possessing the other character. Thus on line 1, column 3, 51.6 means 51.6 per cent of the individuals in the total group have open shaped flowers, and in column 4 the 79.0 means 79.0 per cent of the individuals with tristis scented flowers in this group also have open flowers. Columns 5 and 6 give similar data for Group 1, and columns 7 and 8 for Group II.

TABLE 3

Linkage of other characters to tristis and recurvus fragrance

CHARACTER NO.	FINDINGS	TOTAL GROUP N-852 C. NORM %	group i study #5 revised study #1 N-424 C.	GROUP II STUDY #2-3-6 N-374 C. NORM %
4	Tristis Scented Flowers ARE OPEN SHAPED	51.6 79.0	30.8 28.6	71.4 82.5
	Recurvus Scented Flowers ARE BELL SHAPED	32.9 50.8	56.4 59.1	10.3 15.2
	Coefficient of Contingency	.374	.017	.175
6	Tristis Scented Flowers ARE CURVED TUBED	55.3 66.7	45.1 57.1	61.7 70.5
	Recurvus Scented Flowers ARE STRAIGHT TUBED	44.7 51.1	54.9 55.2	38.3 38.6
	Coefficient of Contingency	.161	.051	.095
8	Tristis Scented Flowers ARE NARROW PETALED	43.8 70.9	27.9 42.8	56.7 69.9
	Recurvus Scented Flowers ARE WIDE PETALED	34.7 51.6	51.3 54.7	20.0 39.1
	Coefficient of Contingency	.409	.096	.395
10	Tristis Scented Flowers LACK GRAINING	68.3 96.5	52.4 85.7	82.3 96.8
	Recurvus Scented Flowers ARE GRAINED	31.7 49.0	47.6 50.5	17.7 43.5
	Coefficient of Contingency	.378	.131	.444
	Tristis Fragrance Recurvatus Fragrance	N 86 10.1 N 252 29.6	N 67 1.7 N204 48.1	N 63 16.9 N 47 12.6

TABLE 3-Continued

CHARACTER NO.	111022100		total group N-852 C.		GROUP I STUDY #5 REVISED STUDY #1 N-424 C.		DY 3-6 374
		NORM	%	NORM	%	NORM	%
12	Tristis Scented Flowers LACK LINES TO TIP Recurvus Scented Flowers	50.6	61.6	35.9		63.5 36.5	60.3
	HAVE LINES TO TIP	49.4	60.6	64.1	05.2	30.3	41.3
in endi	Coefficient of Contingency	.1	91	.0	.075		17
14	Tristis Scented Flowers LACK THROAT DOTS Recurvus Scented Flowers	55.2	80.2	45.2	85.7	60.2	74.6
	HAVE THROAT DOTS	44.8	63.3	54.8	62.7	39.8	67.4
	Coefficient of Contingency	.3	54	.1	77	.3	86
21	Tristis Scented Are Cross Leaf Recurvus Scented	46.5	89.5	15.8	42.9	74.7	92.1
	Are Interm. or Flat Leaf	53.5	81.1	84.2	84.7	25.3	47.7
	Coefficient of Contingency		.538 .172		.346		
22	Tristis Scented ARE GREEN LEAVED	28.1	54.7	11.1	28.6	44.8	55.6
	Recurvus Scented ARE GRAY LEAVED	71.9	90.7	88.9	92.6	55.2	81.4
	Coefficient of Contingency		418		141	.3	346
24	Tristis Scented LACK SHEATH DOTS Recurvus Scented	46.2	63.1	30.0	42.9	58.4	59.0
	HAVE SHEATH DOTS	53.9	69.5	70.0	75.3	41.6	45.5
	Coefficient of Contingency		279		068		046
	Tristis Fragrance Recurvus Fragrance	N 80 N252		N 7		N63 N47	16.9 12.6

In table 3 is shown the linkage of other characters to tristis and recurvus fragrance expressed by means of a coefficient of contigency. Character 21—Leaf Section—shows the strongest linkage to fragrance (C. = .538) and table 4 shows in detail how this coefficient of contingency was computed.

TABLE 4

Note: Selections made from a total group of 852 hybrids.

	TRISTIS FRAGRANCE	RECURVUS FRAGRANCE	-
Cross Leaf Section	77	47	124
Intermediate and Flat Leaf Section	9	202	211
	86	249	
	$\frac{1}{86} \left(\frac{5929}{124} + \frac{8}{2} \right)$	$\left(\frac{1}{11}\right) = .5599$	
	$\frac{1}{249} \left(\frac{2209}{124} + \frac{40}{2} \right)$		
	/ 	P = 1.4079	
	$\sqrt{\frac{.4079}{1.4079}}$ =	$\sqrt{.2897} = \text{C.}.538$	

In order to determine the coefficient of contingency we had to obtain first a measure of probability called P from the square contingency, which may be interpreted by means of a coefficient of contingency. The most valuable form is that derived by Pearson, which he has called C₂ or which we may call C. In its interpretation C is identical with the "product moment coefficient of correlation." It should be particularly noted that if we employ only two classes as the established means of our coefficient of contingency the highest possible coefficient may be only .707; table 4 therefore clearly shows that the relationship; tristis scented flowers are cross-leafed and Recurvus, scented flowers are intermediate or flat-leafed, is a valid one.

A comparison of linkage of these characters to tristis and to recurvus fragrance, expressed as percentage of the total tristis or recurvus fragrant hybrids possessing the character shows as follows:

Character 4. Flower Shape, shows in Group I a relationship of bell shape of flower to recurvus scented—59.1 per cent; both of these characters are strongly represented in this group, but only 15.2 per cent of the recurvus scented are bell shaped in Group II, which is predominantly open rather than bell shaped. The apparent linkage in Group I is reversed in Group II. Tristis scented flowers in Group II show 82.5 per cent open shaped flowers, only 28.6 per cent however in Group I. The apparent relationship of 79 per cent for the total group is not borne out in both sections of it. Accordingly we can only assume there is no consistent linkage of flower shape to either tristis or recurvus fragrance.

Character 6, flower tube curvature, is by similar reasoning to the above, weakly related, curved tube to tristis scented, in Group II 70.5 per cent. Group I, with very few tristis scented plants, shows 57.1 per cent of tristis scent with curved tube. But the converse, straight tube to recurvus scent shows no relationship.

Character 8, narrow petaled, are represented amongst tristis scented 69.9 per cent in Group II, and 42.8 per cent in Group I, which has few of narrow petaled and still fewer tristis scented. Again the converse relation-

ship to recurvus scent is not found.

Character 10, darker graining on the petals, fails to show relationship to recurvus fragrance, being nearly half and half, with and without graining in Group I, Group II and the Total Group. But the absence of graining is strongly represented among the tristis scented plants, 96.8 per cent in Group II, 85.7 per cent in Group I and 96.5 per cent in the Total Group.

Characters 12, 21, and 24 all show reversals in apparent relationships in

the two groups, with regard to tristis and recurvus fragrance.

Character 14, throat dots on the lower lips of the flower, also show a weak relationship, 62.7 per cent and 67.4 per cent in the two groups respectively, while the converse shows even a closer relationship and linkage, 85.7 per cent and 74.6 per cent respectively.

Character 22, leaf color, shows close relationship of recurvus scent to gray leaf 92.6 per cent and 81.4 per cent respectively but none of tristis to

green leaf.

Thus of the nine characters showing a 60 per cent or greater apparent linkage to tristis or recurvus fragrance in the Total Group, only four of them, nos. 6, 10, 14 and 22 show this consistently in Groups I and II. Let us consider the minimum group relationship as most nearly the true one—and this is reasonable, since in breeding with this material, selection of parents was entirely for fragrance, the other characters not being given any consideration, so that they may be regarded as random selections with regard to all except fragrance.

Then tristis scent may be regarded as linked to curved tube (character 6) 57.1%, and to lack of graining (character 10) 85.7%. In each of these cases no converse relationship to recurvus fragrance is found. This further supports the hypothesis already stated that the factors for tristis and for recurvus scent are not allelomorphs. But in the case of character 14, tristis scented lack throat dots 74.6%, and recurvus scented have throat dots 62.7%, thus showing an apparent relationship to each fragrance. If throat dots are dependent on two dominant factors, so that the absence of throat dots is linked to one factor for tristis and the presence

of them is linked to one for recurvus fragrance, it would then fulfill the requirements in this instance. By reference to table 1 the proportion of throat dots found in the first and second generations and back-cross would fit in well with this assumption also, if we assume that the parent of F1 #55, i.e. Recurvus Violet Purple, is homozygous for each of two factors for throat dots, but that the parent of F1#60, Recurvus Bronze, is homozygous for one factor for throat dots, but heterozygous for the other. Grey leaved is apparently linked to recurvus scented, recurvus scented being grey-leaved (character 22) 81.4%, but not tristis scented to green leaved.

The relationship of tristis scented to other characters in Group I is insecure in each case, being based on only seven tristis scented individuals, but the other relationships, based on 47, 63 and 204 individuals respec-

tively, may be regarded as reasonably sure.

CONCLUSION

1. From a study of hybrids of G. tristis with G. recurvus consisting of F₁, F₂ and a back-cross of F₁×tristis, it was found that the violet-like fragrance of G. recurvus was dominant, and the aromatic night scent of G. tristis was recessive.

2. In the F2 and the back-cross two new types of fragrance were ob-

served and designated lemon scented and pungent scented.

3. From a study of the proportions of each type of fragrance and combinations of them in the different groups of hybrids, and from the occurrence of large proportions of scentless F2 and back-cross hybrids it is assumed that each primary type of fragrance is a resultant of the influence of two independent genetic factors, such that two dominant factors are necessary for the expression of recurvus scent, and a dominant and recessive factor for the expression of tristis scent.

4. A preliminary survey of the relationships of the other recorded characters to those for fragrance indicate that the factors for curved flower tube, and for absence of graining of dark color on the flowers are linked each to one factor for tristis scent, that the factors for spotted throat of the flower are linked to both tristis scent and recurvus scent, and that

grey leaf color is strongly linked to recurvus scent.

ACKNOWLEDGEMENTS

In addition to those already mentioned in the text, the writer wishes here to thank both Dr. A. F. Blakeslee and Dr. E. W. Sinnott for their help during the course of this study and in the preparation of this report.

INDEX TO AMERICAN BOTANICAL LITERATURE 1935-1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the

word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

- Acevedo, R. Gramíneas Chilenas de la tribu Paníceas del herbario del Museo Nacional de Historia Natural. Rev. Chilena Hist. Nat. 40: 216-219. f. 22. 1936.
- Adams, J. Some additions to the flora of Prince Edward Island. Canadian Field Nat. 51: 105-107. 7 O 1937.
- Albaum, H. G., Kaiser, S. & Nestler, H. A. The relation of hydrogen-ion concentration to the penetration of 3-indole acetic acid into Nitella cells. Am. Jour. Bot. 24: 513-518. f. 1-4. O 1937.

Fertility and compatibility in Sphaerocarpos. Allen, C. E.

Cytologia Fujii 1: 494-501. Je 1937.

- Anderson, D. B. & Moore, J. H. The influence of constant light and temperature upon the structure of the walls of cotton fibres and collenchymatous cells. Am. Jour. Bot. **24:** 503–507. *f.* 1–9. O 1937.
- Avery, G. S., Burkholder, P. R. & Creighton, H. B. Nutrient deficiencies and growth hormone concentration in Helianthus and Nicotiana. Am. Jour. Bot. 24: 553-557. f. 1-3. O 1937.
- Bailey, I. W. & Kerr, T. The structural variability of the secondary wall as revealed by "lignin" residues. Jour. Arnold Arb. 18: 261-272. pl. 211-214. O 1937.
- Barkley, F. A. A monographic study of Rhus and its immediate allies in North and Central America, including the West Indies. Ann. Missouri Bot. Gard. 24: 265-498. pl. 10-26 +f. 1-30. 27 S 1937.
- Berry, E. W. Succession of fossil floras in Patagonia. Proc. Nat. Acad. Sci. 23: 537-542. O 1937.
- Bishop, G. R. Plants of xeric habitat. Gard. Chron. 41:223-224, 230. illust. Au 1937; 262-263. S 1937.
- Blakeslee, A. F., Bergner, A. D. & Avery, A. G. Geographical distribution of chromosomal prime types in Datura stramonium. Cytologia, Fujii Jub. Vol.: 1070-1093. f. 1-6. Au 1937.
- Bonner, J. & English, J. Purification of traumation, a plant wound hormone. Science II. 86: 352-353. 15 O 1937.

- Box, H. E. & Alston, H. G. Pteridophyta of St. Kitts. Jour. Bot. 75: 241-260. pl. 612. S 1937.
- Brannon, M. A. Algae and growth-substances. Science II.86: 353-354. 15 O 1937.
- Brown, R. W. Fossil legumes from Bridge Creek, Oregon. Jour. Washington Acad. Sci. 27: 414-418. f. 1, 2. 15 O 1937.
- Bullock, A. A. Contributions to the flora of tropical America: XXXI. Plantae Mexicanae Hintonianae: III. Kew Bull. Misc. Inf. 5: 291-310. pl. 10. Tiliaceae contr. by Bullock & T. A. Sprague; Leguminosae contr. by N.Y. Sandwith.
- Buswell, W. M. Orchids of the Big Cypress. American Botanist 43: 147-153. illust. O 1937.
- Carabia, J. P. La familia Cactaceas en Cuba. Mem. Soc. Cubana Hist. Nat. 11: 253-266. O 1937.
- Castellanos, A. & Lelong, H. V. Cactaceas cultivadas que deben excluirse del catalogó de la flora Argentina. Revista Argentina Agron. 1: 213-222. pl. 1, 2. N 1934.
- Catcheside, D. G. The extra chromosome of Oenothera Lamarckiana lata. Genetics 22: 564-576. f. 1-23. N 1937.
- Chandler, C., Porterfield, W. M. & Stout, A. B. Microsporogenesis in diploid and triploid types of *Lilium tigrinum* with special references to abortions. Cytologia, Fujii Jub. Vol.: 756-784. pl. 24-26+f. 1-11. Au 1937.
- Chandler, R. F. Certain relationships between the calcium and oxalate content of foliage of certain forest trees. Jour. Agr. Res. 55: 393-396. 1 S 1937.
- Chapman, H. D., Vanselow, A. P. & Liebig, G. F. The production of *Citrus* mottle-leaf in controlled nutrient cultures. Jour. Agr. Res. 55: 365-379. f. 1-6. 1 S 1937.
- Chavan, A. R. A morphological study of Cyathodium barodae. / Am. Jour. Bot. 24: 484-492. f. 1-83. O 1937.
- Chupp, C. Cercospora species and their host genera. 1-23. Cornell Univ. Ithaca. New York. S 1937.
- Coffman, F. A. Factors influencing seed set in oat crossing. Jour. Heredity 28: 297-303. f. 1-3. S 1937.
- Cory, V. L. Some new plants from Texas. Rhodora 39:417-423. O 1937.
- Creager, D. B. Phytophthora crown rot of dogwood. Jour. Arnold Arb. 18: 344-348. pl. 216. O 1937.
- Cullinan, F. P. Improvement of stone fruits. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 665-748. f. 1-20. 1937.
- Davis, J. J. Notes on parasitic fungi in Wisconsin. XX. Trans. Wisconsin Acad. Sci. 30: 1-15. 1937.

- Davis, L. D. The gumming of Phillips cling peaches. Hilgardia 11: 1-34. f. 1-22. Je 1937.
- Davy, J. B. Note on Argyrodendron F. Muell. Tropical Woods 51: 19-20. 1 S 1937.
- Diels, L. Beiträge zur Kenntnis der Vegetation und Flora von Ecuador. Bibliotheca Bot. 116: 1–190. f. 1, 2. 1937.
- Dodge, B. O. Spindle orientation and spore delimitation in *Gelasinospora tetrasperma*. Cytologia, Fujii Jub. Vol.: 877-887. pl. 32, 33. Au 1937.
- Drew, W. B. Notes on Aster in eastern Tennessee. Castanea 2: 75-81. O 1937.
- Drouet, F. Three American Oscillatoriaceae. Rhodora 39: 277-280. f. 1-3. 13 Au 1937.
- Dunlap, A. A. & Livingston, B. E. Distribution and movement of potassium nitrate in sand cultures, as related to irrigation and to porosity of container wall. Am. Jour. Bot. 24: 500-503. f. 1. O 1937.
- Erickson, H. D., Schmitz, H. & Gortner, R. A. The permeability of woods to liquids and factors affecting the rate of flow. Univ. Minnesota Agr. Exp. Sta. Tech. Bull. 122: 1-42. f. 1. Jl 1937.
- Fassett, N. C. Notes from the herbarium of the University of Wisconsin. XIV. Rhodora 38: 187-191. f. 1. My 1936; XV. 39: 377-379. O 1937.
- Fassett, N. C. Preliminary reports on the flora of Wisconsin. XXV. Arales. Trans. Wisconsin Acad. Sci. 30: 17-20. f. 1-10. 1937.

 The Lemnaceae in collaboration with L. E. Hicks.
- Fogelberg, S. O. Preliminary reports on the flora of Wisconsin. XXVI. Convolvulaceae. Trans. Wisconsin Acad. Sci. 30: 22-25. f. 1-10. 1937.
- Friesner, R. C. Indiana as a critical botanical area. Proc. Indiana Acad. Sci. 46: 28-45. 1937.
- Fulford, M. Some Cladoniae from southwestern Ohio. Cladoniae from Clermont, Brown, and Adams Counties. Ohio Jour. Sci. 37: 295–300. S 1937.
- Goodspeed, T. H. Significance of cytogenetic alterations induced by high frequency radiation in *Nicotiana* species. Cytologia, Fujii Jub. Vol.: 961-966. Au 1937.
- Goss, W. L. Germination of flower seeds stored for ten years in the California state seed laboratory. California Dep. Agr. Bull. 26: 326-333. Jl-S 1937.

- Gray, W. D. Observations on the methods of stipe-formation in *Stemonitis* and *Comatricha*. Proc. Indiana Acad. Sci. 46: 81-85. f. 1. 1937.
- Greenfield, S. S. Responses of stock seedlings to heteroauxin applied to the soil. Am. Jour. Bot. 24: 494-499. f. 1-6. O 1937.
- Harper, R. M. Mimicry in two southern weeds. Torreya 37: 104-108. S-O 1937.
- Hatch, A. B. The physical basis of mycotrophy in *Pinus*.

 Black Rock Forest Bull. 6: i-x+1-168. pl. 1-16+f. 1-21.

 1937.
- Henderson, L. Studies on the infection of cotton seedlings by *Phymatotrichum omnivorum*. Am. Jour. Bot. 24: 547-552. f. 1-3. O 1937.
- Höeg, O. A. The Devonian floras and their bearing upon the origin of vascular plants. Bot. Rev. 3: 563-592. f. 1-6. N 1937.
- Hunter, J. W. & Dalbey, N. E. A histological study of stalk-breaking in maize. Am. Jour. Bot. 24: 492-494. f. 1, 2. O 1937.
- Huskins, C. L. The internal structure of chromosomes—a statement of opinion. Cytologia, Fujii Jub. Vol.: 1015—1022. pl. 36, 37. Au 1937.
- Inge, F. D. & Loomis, W. E. Growth of the first internode of the epicotyl in maize seedlings. Am. Jour. Bot. 24: 542– 547. f. 1-6. O 1937.
- Jeffrey, E. C. The somatic chromosomes of *Trillium*. Cytologia, Fujii Jub. Vol.: 857-866. f. 1-4. Au 1937.
- Jenkins, A. E. New species of *Sphaceloma* on *Aralia* and *Mentha*. Jour. Washington Acad. Sci. 27: 412-414. f. 1. 15 O 1937.
- Johnson, A. M. Seedlings from polyembryonic seeds of *Eugenia Hookeri*. Madroño 4: 115-118. pl. 19. 4 O 1937.
- **Johnson, J.** An acquired partial immunity to the tobacco streak disease. Trans. Wisconsin Acad. Sci. 30: 27-34. f. 1-6. 1937.
- Johnson, J. & Hoggan, I. A. The inactivation of the ordinary tobacco-mosaic virus by microorganisms. Phytopathology 27: 1014-1027. f. 1. O 1937.
- Johnson, T. & Newton, M. The effect of high temperature on uredial development in cereal rusts. Canadian Jour. Res. 15^c: 425-432. f. 1, 2. S 1937.
- Jones, D. F. Somatic segregation and its relation to atypical growth. Genetics 22: 484-522. pl. 1+f. 1-20. S 1937.

- Jones, H. A. Onion improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 233–250. f. 1–5. 1937.
- Jones, W. N. Chimaeras: a summary and some special aspects. Bot. Rev. 3: 545-562. f. 1. N 1937.
- Juzepczuc, S. & Bukasov, S. Nuevas especies de Solanum de la flora Argentina. Revista Argentina Agron. 3: 225-228. D 1936.
- Keck, D. D. Studies in Penstemon, III. Madroño 3: 248-250. Ap 1936.
- Keck, D. D. Studies in *Penstemon*, IV. The section Ericopsis. Bull. Torrey Bot. Club 64: 357-381. Je 1937.
- Kevorkian, A. G. Studies in the Entomophthoraceae. I. Observations on the genus *Conidiobolus*. Jour Agr. Univ. Puerto Rico 21: 191–200. pl. 9-11. Jl 1937.
- King, J. R. & Bamford, R. The chromosome number in *Ipomoea* and related genera. Jour. Heredity 28: 279-282. f. 3. Au 1937.
- Lackey, C. F. Restoration of virulence of attenuated curly top virus by passage through susceptible plants. Jour. Agr. Res. 55: 453-460. f. 1-6. 15 S 1937.
- Lawrence, J. R. A correlation of the taxonomy and the floral anatomy of certain of the *Boraginaceae*. Am. Jour. Bot. 24: 433-444. f. 1-58. Jl 1937.
 - Leon, Brother. Leptocereus (Berger) Britton and Rose. Jour. Cactus & Succ. Soc. Am. 9: 11-13. illust. Jl 1937.
 - Levandowsky, D. W. Effects of altitude and exposure on certain plants of the Blue Ridge. Shenandoah Nat. Jour. 14: 9-12. illust. 1937.
 - Levine, M. & Chargaff, E. The response of plants to chemical fractions of *Bacterium tumefaciens*. Am. Jour. Bot. 24: 461-472. f. 1-67. Jl 1937.
 - Lindquist, J. C. La "Quemadura" de las hojas de narcisos y junquillos (*Stagonospora Curtisii*). Revista Argentina Agron. 2: 237–244. f. 1–4. D 1935.
 - Livingston, B. E. Foliar transpiring power: its estimation by means of standardized hygrometric paper slips. Bot. Mag. Japan 51: 407-425. f. 1-4. Je 1937.
 - Lloyd, C. E. & Steinmetz, F. H. Temperature as a factor influencing the sexual response of *Marchantia*. Am. Jour. Bot. 24: 423-425. Jl 1937.
 - Lojkin, M. A study of ascorbic acid as an inactivating agent of tobacco mosaic virus. Contr. Boyce Thompson Inst. 8: 445-465. f. 1-4. Ap-Je 1937.

- McAtee, W. L. Some local names of plants—VI. Torreya 37: 93-103. S-O 1937.
- McKee, R. & Pieters, A. J. Miscellaneous forage and cover crop legumes. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 999-1031. f. 1-6. 1937.
- McKinney, H. H. Mosaic diseases of wheat and related cereals. U. S. Dep. Agr. Circ. 442: 1-22. f. 1-13. S 1937.
- McVeigh, I. Vegetative reproduction of the fern sporophyte. Bot. Rev. 3: 457-497. S 1937.
- Magness, J. R. Progress in apple improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 575-614. f. 1-8. 1937.
- Magness, J. R. Progress in pear improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 615-630. f. 1-6. 1937.
- Magness, J. R. Vegetative production. U.S. Dep. Agr. Yearbook Agr. Res. 1937: 1450-1456. f. 1-3. 1937.
- Magruder, R. Improvement in the leafy cruciferous vegetables. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 283-299. f. 1-3. 1937.
- Marchionatto, J. B. Contribucion al conocimiento de la biologia de la Rosellinia necatrix. Revista Argentina Agron. 3: 153-158. pl. 11, 12. S 1936.
- Marchionatto, J. B. Influencia del medio sobre la predisposición de las plantas a las enfermedades. Revista Argentina Agron. 1: 111-115. Au 1934.
- Markgraf, Fr. Der Formenkreis von Aspidosperma quebrachoblanco Schltd. Notizbl. Bot. Gart. Berlin 13: 464-467. 30 Je 1937.
- Markgraf, Fr. Die Gattung *Paralyxia* Baill. Notizbl. Bot Gart. Berlin 13: 456–459. 30 Je 1937.
- Markgraf, Fr. Neue andine Melastomataceen II. Notizbl. Bot. Gart. Berlin 13: 459-464. 30 Je 1937.
- Martin, G. W. New or noteworthy fungi from Panama and Colombia. I. Mycologia 29: 618-625. f. 1-9. S-O 1937.
- Martin, W. E. Chemical study of the ripening process of Bosc pears. Bot. Gaz. 99: 42-68. f. 1-5. 27 S 1937.
- Maxon, W. R. & Morton, C. V. A new species of *Dryopteris* subgenus *Eudryopteris*, from Guatemala. Proc. Biol. Soc. Washington 50: 179-180. 28 O 1937.
- Merrill, E. D. Miscellanea Sinensia. Sunyatsenia 3: 246-262. pl. 32. Au 1937.
- Merrill, E. D. On the significance of certain Oriental plant names in relation to introduced species. Proc. Am. Philos. Soc. 78: 111-146. 22 O 1937.

- Merrill, E. D. Polynesian botanical bibliography. Benice P. Bishop Mus. Bull. 144: 1-194. 1937.
- Merrill, E. D. & Perry, L. M. Reinstatement and revision of *Cleistocalyx* Blume (including *Acicalyptus* A. Gray), a valid genus of the Myrtaceae. Jour. Arnold Arb. 18: 322-343. pl. 215. O 1937.
- Meyer, T. Caracteristicas de la flora del departamento de resistencia (Chaco). Revista Argentina Agron. 2: 349-358. Ja 1936.
- Mielke, J. L., Childs. T. W. & Lachmund, H. G. Susceptibility to *Cronartium ribicola* of the four principal *Ribes* species found within the commercial range of *Pinus monticola*. Jour. Agr. Res. 55: 317-346. f. 1-6. 1 S 1937.
- Milanez, F. Notas sobre duas galhas brasileiras. Rodriguesia 2: 131-142. pl. 1-8+f. 1. 1937.
- Milbrath, J. A. An indication of seed transmission of mosaic virus in tomato seed. Phytopathology 27: 868-869. Au 1937.
- Miller, L. P. Decomposition of ethylene chlorhydrin in potato tubers. Contr. Boyce Thompson Inst. 8: 479-492. Ap-Je 1937.
- Mitchell, H. L., Finn, R. F. & Rosendahl, R. O. The relation between mycorrhizae and the growth and nutrient absorption of coniferous seedlings in nursery beds. Black Rock Forest Papers 1: 58-73. pl. 1, 2+f. 1, 2. 1937.
- Mitchell, J. W. & Martin, W. E. Effect of indoleacetic acid on growth and chemical composition of etiolated bean plants. Bot. Gaz. 99: 171–183. f. 1–4. 27 S 1937.
- ►Möbius, M. Geschichte der Botanik von den ersten Anfängen bis zur Gegenwart. i-vi+1-458. Gustav Fischer. Jena 1937.
- Moyer, L. S. Recent advances in the physiology of latex. Bot. Rev. 3: 522-544. O 1937.
- Nichol, A. A. The natural vegetation of Arizona. Univ. Arizona Agr. Exp. Sta. Tech. Bull. 68: 181-222. pl. 1-22+f. 1. 15 Jl 1937.
- Nielsen, E. L. Grass studies. II. Additions to the flora of Arkansas. Rhodora 39: 423-424. O 1937.
- Nobles, M. K. Production of conidia by Corticium incrustans. Mycologia 29: 557-566. f 1-26. S-O 1937.
- Overbeek, J. van & Went, F. W. Mechanism and quantitative application of the pea test. Bot. Gaz. 99: 22-41. f. 1-8. 27 S 1937.

- Peattie, D. C. Autumal notes from the Carolina Blue Ridge. Castanea 2: 67-73. My 1937.
- Peck, M. E. Some new species and varieties of Oregon plants. Proc. Biological Soc. Washington 50: 121-123. 7 Au 1937.
- Peebles, R. H. Comments on the dry-fruited cylindric Opuntias of Arizona. Jour. Cactus & Succ. Soc. Am. 9: 35-38. illust. S 1937.
- Perry, L. M. Notes on *Silphium*. Rhodora 39: 281-297. Au 1937.
- Pfeiffer, N. E. Anatomical study of root production on application of indolebutyric acid to *Cissus* aerial roots. Contr. Boyce Thompson Inst. 8: 493–506. f. 1–6. Ap–Je 1937.
- Philippis, A. de. Su alcuni legnami Brasiliani. L'Alpe Rev. Forest Ital. 24: 268-276. f. 1-7. Jl 1937.
- Pierce, W. H. Legume viruses in Idaho. Phytopathology 27: 836-843. f. 1, 2. Au 1937.
- Pieters, A. J. & Hollowell, E. A. Clover improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 1190-1214. f. 1-7. 1937.
- Pilger, R. Species nonnullae brasilienses novae. II. Repert. spec. nov. 42: 173-181. 30 Je 1937.
- Poellnitz, K. von. Five little known species of the genus Haworthia Duval. Desert 9: 90-91. illust. Au 1937.
- **Poole, C. F.** Improvement of sweet corn. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 379–394. f. 1-4. 1937.
- Poole, C. F. Improving the root vegetables. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 300-325. f. 1-4. 1937.
- Potzger, J. E. Notes on Indiana grasses, 1936. Proc. Indiana Acad. Sci. 46: 79-80. 1937.
- Potzger, J. E. & Friesner, R. C. Soil acidity and hemlock reproduction in relic colonies in Indiana. Proc. Indiana Acad. Sci. 46: 93-99. f. 1-4. 1937.
- Potzger, J. E. & Geisler, F. Some physical features associated with pliability of wood. Proc. Indiana Acad. Sci. 46: 88–92. f. 1–7. 1937.
- Porterfield, W. M. Histogenesis in the bamboo with special reference to the epidermis. Bull. Torrey Club 64: 421-432. pl. 9+f. 5-12. O 1937.
- Pratt, R. & Curry, J. Growth of roots in deuterium oxide. Am. Jour. Bot. 24: 412-416. f. 1-3. Jl 1937.
- Prescott, G. W. & Croasdale, H. T. New or noteworthy fresh water algae of Massachusetts. Trans. Am. Microscop. Soc. 56: 269-282. pl. 1-3. Jl 1937.

- Privault, D. Contribution à l'étude de la flore de la Martinique. Bull. Soc. Bot. France 84: 289-294. My-Je 1937.
- Puttemans, A. Computo das especies de "ferrugens" verdadeiras (Uredinales) assignaladas no Brasil e paizes limitrophes. Rodriguesia 2: 97–105. 1937.
- Raber, O. Water utilization by trees, with special reference to the economic forest species of the north temperate zone. U. S. Dep. Agr. Misc. Publ. 257: 1-97. Je 1937.
- Rao, V. N. R. New cotton varieties from a species cross. Mysore cottons and their improvement—II. Jour. Heredity 28: 311-316. f. 4-6. S 1937.
- Raper, K. B. Growth and development of *Dictyostelium discoideum* with different bacterial associates. Jour. Agr. Res. 55: 289-316. f. 1-4. 15 Au 1937.
- Record, S. J. & Hess, R. W. Aids in identifying American timbers of the order Malvales. Tropical Woods. 51: 1-10. 1 S 1937.
- Rehder, A. Notes on the ligneous plants described by H. Leveille from eastern Asia. Jour. Arnold Arbor. 17: 316-340. 22 O 1936; 18: 26-53. Ja 1937; 273-321. O 1937.
- Reid, M. E. Localization of ascorbic acid in the cowpea plant at different periods of development. Am. Jour. Bot. 24: 445-447. Jl 1937.
- Reinking, O. A. Isolations made from heart rot of banana in Honduras. Phytopathology 27: 853-854. Au 1937.
- Rendle, A. B. The Linnaean species of Rauvolfia (Plum.) Linn. Proc. Linnaean Soc. London 149: 106-109. pl. 3. 23 S 1937.
- Riker, A. J. & Riker, R. S. Introduction to research on plant diseases. 1-117. f. 1-17. John S. Swift Co. 16 S 1936.
- Riviera, R., Popp, H. W. & Dow, R. B. The effect of high hydrostatic pressures upon seed germination. Am. Jour. Bot. 24: 508-513. O 1937.
- Robbins, W. J. & Bartley, M. A. Use of dextrose by excised tomato roots. Science II. 86: 290-291. 24 S 1937.
- Robbins, W. J. & Kavanagh, F. Intermediates of vitamin B₁ and growth of *Phycomyces*. Proc. Nat. Acad. Sci. 23: 499-502. S 1937.
- Rombouts, J. Uma molestia de "Eucalyptus" e de "Populus," na Bahia, causada por "Corticium salmonicolor" B. et Bred. Rodriguesia 2: 301–305. illust. D-Mr 1936.
- Rousseau, J. La botanique Canadienne à l'époque de Jacques Cartier. Contr. Lab. Bot. Univ. Montreal 28: 1-86. 1937.

- Rousseau, J. Les tourbieres littorales: indice de la submersion de la côte sud-est de la nouvelle-écosse. Nat. Canadien 64: 197-206. f. 1-4. Au-S 1937.
- Rowntree, L. Hardy Californians. i-xiv+1-255. illust. Macmillan Co. New York. 1936.
- Rudof, W. & Job, M. M. Consideraciones sobre el fenómeno de la resistencia a las royas en el trigo. Revista Argentina Agron. 2: 24-30. Ap 1935.
- Ruehle, G. D. A strain of *Alternaria citri* Ellis and Pierce causing a leaf spot of rough lemon in Florida. Phytopathology 27: 863–865. f.1. Au 1937.
- Ruiz, O. M. Contribucion al conocimiento de los liquenes de valle del Mezquital. An. Inst. Biol. Mexico 8: 118–131. f. 1–15. 1937.
- Runyon, H. E. Distribution of seeds by dust storms. Trans. Kansas Acad. Sci. 39: 105-113. 1937.
- Ruttle, M. L. & Nebel, B. R. Chromosome structure XI. Hordeum vulgare L. and Secale cereale L. Cytologia Fujii 1: 553-568. f. 1-15. Je 1937.
- St. Johns, H. A new *Thalictrum* from Mount Rainier, Washington. Madroño 4: 114, 115. f. 1. 4 O 1937.
- Salaman, R. N. The potato in its early home and its introduction into Europe. Jour. Royal Hort. Soc. 62: 61-77. f. 1-17. F 1937; 253-266. Je 1937.
- Sandwith, N. Y. Phlox bifida var. glandifera. Curtis's Bot. Mag. 160: pl. 9498. 28 S 1937.
- Satina, S. & Blakeslee, A. F. Chromosome behavior in triploids of *Datura stramonium*. I. The male gametophyte. Am. Jour. Bot. 24: 518-527. f. 1-7. O 1937.
- Sax, K. Chromosome behavior and nuclear development in *Tradescantia*. Genetics 22: 523-533. pl. 1+ f. 1, 2. S 1937.
- Sax, K. Chromosome inversions in Paeonia suffruticosa. Cytologia Fujii 1: 108-114. pl. 4+f. 1-10. Je 1937.
- Schaffner, J. H. Additions to the revised catalog of Ohio vascular plants, V. Ohio Jour. Sci. 37: 260-265. Jl 1937.
- Schaffner, J. H. Examples of orthogenetic series in plants and animals. Ohio Jour. Sci. 37: 267-287. f. 1, 2. S 1937.
- Schmoll, H. M. A new variety of *Elymus virginicus* L. Rhodora 39: 416, 417. O 1937.
- Schreiner, E. J. Improvement of forest trees. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 1242–1279. f. 1–14. 1937.
- Scott, F. M. Differentiation of the spiral vessels in *Ricinus communis*. Bot. Gaz. 99: 69-79. f. 1-21. 27 S 1937.

- Sealy, J. R. Amelanchier florida forma tomentosa. Curtis's Bot. Mag. 160: pl. 9496. 28 S 1937.
- Sealy, J. R. Leptochiton quitoensis. Curtis's Bot. Mag. 160: pl. 9491. 28 S 1937.
- Sealy, J. R. Mutisia oligodon. Curtis's Bot. Mag. 160: pl. 9499. 28 S 1937.
- Sealy, J. R. Notes on *Colletia* species. Kew Bull. Misc. Inf. 6: 325-333. 1937.
- Setchell, W. A. Nathaniel Lyon Gardner. Madroño 4: 126-128. pl. 21. 4 O 1937.
- Sherff, E. E. The genus *Bidens*. Field Mus. Nat. Hist. Bot. Ser. 16: 1-346. pl. 1-88. 31 Au 1937; 347-709. pl. 89-189. 21 S 1937.
- Shreve, F. The vegetation of the Cape Region of Baja California. Madroño 4: 105-113. pl. 18+f. 1. 4 O 1937.
- Silveira, F. Convergencia de caracteres. Rodriguesia 2: 271–273. illust. D-Mr 1936.
- Singh, B. N. & Mathur, P. B. Negative correlation between the occurrence of polyphenol oxidase and diastase and the degree of incidence of "blackheart" of potato. Phytopathology 27: 992–1000. O 1937.
- Smith, A. C. A Colombian species of *Cervantesia* R. & P. Tropical Woods 51: 12-14. 1 S 1937.
- Smith, A. H. Notes on agarics from the western United States. Bull. Torrey Club 64: 477-486. pl. 10, 11. O 1937.
- Smith, C. O. Crown gall on incense cedar, *Libocedrus decurrens*. Phytopathology 27: 844–849. f. 1–3. Au 1937.
- Smith, D. C. Varietal improvement in hops. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 1215-1241. f. 1-7. 1937.
- Snow, A. G. Transpiration as modified by potassium. Plant Phsiol. 11: 583-594. f. 1-4. 1936.
- Snyder, E. Grape development and improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 631-664. f. 1-8. 1937.
- Souèges, R. L'embryon chez les Amarantus. Relations embryologiques entre les Solanacées et les Centrospermales. Bull. Soc. Bot. France 84: 242-255. f. 1-48. My-Je 1937.
 - Sparrow, F. K. Some Chytridiaceous inhabitants of submerged insect exuviae. Proc. Am. Philos. Soc. 78: 23-53. pl. 1-4+f. 1-5. 22 O 1937.
 - Stacey, J. W. Notes on *Carex*-X. Leafl. West. Bot. 2: 39-40. 26 Au 1937.
 - Stahl, A. Estudios sobre la flora de Puerto Rico. ed. II. 3: 1-373. Publ. Fed. Emerg. Relief Admin. Puerto Rico. 1936.

- Standley, P. C. Flora of Coasta Rica. Part I. Field Mus. Nat. Hist. 18: 1-398. 12 O 1937; Part II. 401-880. 20 O 1937.
- Standley, P. C. Studies of American plants—VII. Field Mus. Nat. Hist. Bot. Ser. 17: 155-224. 28 S 1937.
- Standley, P. C. The genus Ampelocera in Central America. Tropical Woods 51: 11-12. 1 S 1937.
- Stebbins, G. L. Critical notes on the genus *Ixeris*. Jour. Bot. 75: 43-51. F 1937.
- Steiner, M. Die Pflanzengesellschaften der Salzmarschen in den nordöstlichen Vereinigten Staaten von Nordamerika. Repert. spec. nov. Beihl. 81^c: 108-128. pl. 4-8. 1935.
- Stevenson, F. J. & Clark, C. F. Breeding and genetics in potato improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 405-444. f. 1-9. 1937.
- Stewart, P. A. & Merrell, W. D. The Bergen Swamp: an ecological study. Proc. Rochester Acad. Sci. 7: 209-262. f. 1-4. Au 1937.
- Stokes, S. G. Further studies in *Eriogonum*—I. Leafl. West. Bot. 2: 45-48. 26 Au 1937.
- Stout, A. B. Some observations on flower behavior in Amorphophallus titanum. Jour. N.Y. Bot. Gard. 38: 197-200. f. 6. Au 1937.
- Swezy, O. Alterations in somatic chromosomes in *Crepis*. Cytologia Fujii 1: 149-155. f. 1-11. Je 1937.
- Sydow, H. Novae fungorum species—XXV. Ann. Myc. 35: 244-286. 1937.
- Thimann, K. V. On the nature of inhibitions caused by auxin. Am. Jour. Bot. 24: 407-412. f. 1-2. Jl 1937.
- **Thompson, R. C.** Improvement of salad crops. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 326–339. f. 1, 2. 1937.
- Thompson, W. P. & Thompson, M. G. Reciprocal chromosome translocations without semi-sterility. Cytologia Fujii 1: 336-342. f. 1-11. Je 1937.
- Tiffany, L. H. Oedogoniales. North American Flora 2¹: 1-102. pl. 1-36. 24 S 1937. Bibliography by J. H. Barnhart.
- Torrey, R. H. Collecting Cladoniae south of the Delaware capes. Castanea 2: 82-86. O 1937.
- Traub, H. P. & Robinson, T. R. Improvement of subtropical fruit crops: citrus. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 749–826. f. 1–19. 1937.
- Trelease, S. F. & Trelease, H. M. Toxicity to insects and mammals of foods containing selenium. Am. Jour. Bot. 24: 448-451. f. 1. Jl 1937.

DIRECTORY OF DEALERS

IN MATERIALS OF SCIENCE

The firms listed in this section represent reputable dealers in materials for the laboratory, library, greenhouse, field and garden.

Before you make your purchases consult these firms.

You are assured of courteous treatment and an ample discount.

Mention the BULLETIN

CHEMICALS and REAGENTS



for

Histology, Physiology, and Bacteriology

Our stock of C. P. and U. S. P. chemicals is ample and varied, enabling us to give prompt service on your orders, at correct current prices.

We also carry in stock the various stains, and fixing, mounting, and embedding media, used in the histological laboratory.

Try Us For Your Next Requirements

NEW YORK SCIENTIFIC SUPPLY CO.

Formerly—New York Biological Supply Co.
111-113 East 22nd Street New York, N.Y.

Distributors of Baker's, Mallinckrodt's, and other high grade chemicals.

Studies in Onagraceae XI. A revision of the genus Gaura

PHILIP A. MUNZ

(concluded)

. 11. GAURA BRACHYCARPA Small, Flora S.E. U. S., 848, 1335. 1903.

Apparently a winter annual, branched at base, the stems simple or again branched, very slender, decumbent, 1-3.5 dm. long, finely hirsute in leafy part; rosette-leaves oblanceolate, 4-6 cm. long, remotely sinuate-dentate, obtuse, gradually narrowed into short winged petioles, somewhat villous; cauline leaves on lower half of stems, the blades thin, mostly lance-ovate, sinuate-denticulate to subentire, 1.5-4 cm. long, 5-12 mm. wide, acute to obtuse, somewhat cuneate, sparsely villous, sometimes linear-lanceolate; spikes few-flowered, slender, strigulose, somewhat peduncled, nodding at tip, 5-20 cm. long; hypanthium strigulose, slender, 4-7 mm. long, copiously whitepubescent within; sepals 6-8 mm. long, strigulose, linear, reflexed separately in anthesis; petals white, aging pink, spatulate, 6-8 mm. long; stamens subequal, filaments flattened, 4-5 mm. long, with basal scale; anthers reddish, ca. 2 mm. long; style pubescent at base, somewhat surpassing stamens; stigma-lobes about two-thirds mm. long; capsule elongate-pyramidal, 5-7 mm. long, subglobose, flat at base, 4-angled, the angles auricled at base, the faces transversely wrinkled; seeds few.

Type locality, San Diego, Texas. Ranging rather widely in eastern Texas. Representative material, TEXAS: Dallas, Reverchon in 1874 (G); 6 mi. northwest of Valley Springs, Llano Co., Cory 6269 (P); San Marcos, Hayes Co., Stanfield in 1897 (NY); West Cave, Blanco Co., Bogusch 713 (US); San Antonio, Jermy 254 (NY), Clemens 687 (P); Sutherland Springs, Wilson Co., Jones in 1932 (P); Corpus Christi, Nueces Co., Heller 1391 (G, NY, US); Kingsville, Kleberg Co., Jones 29568 (P); Sabinal, Uvalde Co., Jones in 1932 (P); Carrizo Springs, Dimmit Co., Jones 28141 (P) Laredo, Webb Co., Palmer 11264 (G, NY, US); San Diego, Duval Co., Croft 109, type (NY).

This species is characterized by its slender decumbent stems, its strigulose buds, and pyramidal auricled fruit.

12. GAURA TRIPETALA Cav., Icones 4: 66, pl. 396. 1797.

Apparently annual to short-lived perennial, usually branched from base stems rather slender, simple or branched, ascending, hirsute, often reddish, 2-6 dm. long; basal leaves oblanceolate, sinuate-dentate, 4-8 cm. long, narrowed into short winged petioles, more or less pubescent, especially on veins and margins; cauline leaves lanceolate to oblong-linear, entire to sinuate-

[The Bulletin for March (65: 135-209) was issued March 1, 1938]

dentate, sometimes wavy, almost or quite sessile, 2–5 cm. long, almost glabrous to pubescent, acuminate to obtuse; spikes 1–3 dm. long, somewhat peduncled; hypanthium 4–5 mm. long, slender, often reddish, pubescent within; sepals 3, narrow, 4–6 mm. long, usually distinct in anthesis; petals 3, oblanceolate, 3–4 mm. long, red in age; stamens 6, subequal; filaments 3–4 mm. long; anthers often red, 1–1.5 mm. long; style pubescent at base; capsule ovoid-pyramidal, sharply 3-angled, 4–8 mm. long, each face with median rib and transverse wrinkles.

KEY TO VARIETIES

Inflorescence glandular-pubescent. Hidalgo to Puebla		12a.	G.	tripetala	var.	typica
Inflorescence not glandular.						
Buds strigose. Texas to Durango		12b.	Ğ.	tripetala	var.	Coryi
Buds glabrous, Oklahoma	12c.	G. tr	ipe	tala var.	trian	gulata

12a. Gaura tripetala Cav. var. typica n.nom.

G. tripetala Cav., Icon. 4: 66, pl. 396. 1797. G. hexandra Ortega, Hort. Matr. Dec., 14, 1797; Sessé & Moc., Pl. N. Hispan., ed. 1, 56. 1887–'90.

Inflorescence, hypanthium, calyx and ovary glandular-puberulent.

Type locality, "Prope Pachuca et San Agustin," Hidalgo, Mex. Ranging in central Mexico. Material seen, WITHOUT LOCALITY: G. tripetala ex herb. Madrid, A. Gray, 1880 (G); Jard. des Plantes, in 1815 (G); Mexico, Ruiz (Ber, photos at G, P); G. hexandra, Sessé, Mociño, Castillo, & Maldonado 5147 & 936 (Madrid) FEDERAL DISTRICT; Tultenango, Rose & Painter 7840 (US); Eslava, Rusby 123 (NY), Rose & Painter 7145 G, US); valley of Mexico, Pringle 9795 in part (G, US); Tolucca, Berlandier 1099 (US); Ixtaccihuatl, Purpus in 1903 (US). PUEBLA: Rte. de Cholula, Puebla, Arsène 900 (NY, US); Cerro et fort de Guadelupe, Arsène in 1908 (NY, US); Laguna de San Baltasar, Arsène 1113 (US).

12b. G. tripetala Cav. var. Coryi n.var.

Hypanthium, sepals, usually ovaries strigulose. (Hipantium, sepala, et plenunque ovaria strigulosa).

Type, dry banks, Hempstead, Waller Co., Texas, E. Hall 211, April 25, 1872, Pomona College Herbarium No. 39283; isotypes (G, NY, US). Texas and northern Mexico. Representative material, TEXAS: without locality, Wright 205 (G, US), Drummond III, 82 (NY); Bryan, Brazos Co., Palmer 7794 (NY, US); Encino (Encinal?), La Salle Co., Jones 29567 (P); near San Angelo, Tom Green Co., Cory 8824 (P); Olney, Young Co., Cory 13142 (P). MEXICO: without locality, Coulter 163 (G); Aguascalientes, Rose & Painter 7786 (NY, US); Saltillo, Gregg 29 (G); La Quemada, Zacatecas, Seler 4790 (G); Durango, E. Palmer 257, in 1896 (G, NY, US). It is a pleasure to name this new variety for my friend Mr. V. L. Cory of

Sonora, Texas, who has done so much interesting work in recent years on the flora of his state.

12c. Gaura tripetala Cav. var. triangulata (Buckl.) n. comb.

G. triangulata Buckl., Proc. Acad. Sci. Philad. 1861: 454. 1862. Hypanthium, calyx, and ovaries glabrous.

Type locality, "Prairies Northern Texas," May, S. B. Buckley. I have seen the following material, OKLAHOMA: Cache, Comanche Co., Stevens 1325 (G, NY); Ft. Sill, Domanche Co., Clemens 11709 (G); Catoosa, Rogers Co., Bush 1131 (NY); Oklahoma City, Carleton 129 (US). An intergrade with var. Coryi is: 15 miles east of Tulsa, Engelman in 1935 (P).

I am indebted to Dr. Francis Pennell of the Philadelphia Academy for examining and reporting to me on the glabrous condition of Buckley's type.

I should add, before going on to the next species, that I have some misgiving as to the recognition of Gaura tripetala as a species. Its chief claim to specific rank is its tripetalous and trisepalous condition. But after studying G. angustifolia and finding flowers on the same plant built on both the plan of 3 and that of 4, I am somewhat dubious as to the value of this character. Furthermore, some sheets referred to G. tripetala seem more like one species, others like another. For example, Palmer 257 from Duango seems very much like G. gracilis, while most Texas plants are more like G. brachycarpa. I am therefore not at all sure that all are conspecific. However, since in Texas and Mexican material I have seen no such variation in number of floral parts as in the Florida species angustifolia, and since without much cytological and garden evidence, further status cannot be determined, I am forced for the present to recognize G. tripetala.

13. GAURA VILLOSA TOTT., Ann. Lyc. N.Y. 2: 200, 1828.

Perennial, usually suffrutescent, stems several from base, ascending-erect, mostly 5–10 dm. tall, with several divergent lateral leafy branches closely placed and at a distance of 2–3 dm. above the base, often with another similar umbellate group further up the stem; stems canescent or rather stiffly appressed-villous; leaves numerous, crowded, canescent, appressed-villous, more or less undulate, the lower ones spatulate to ovate or lanceolate, mostly sinuate-serrate or -denticulate, acuminate to obtuse, 3–7 cm. long, 8–25 mm. wide, narrowed at base, subsessile or short-petioled, upper ones linear to lanceovate, 1.5–2 cm. long, 3–15 mm. wide; floral bracts ovate to ovate-lanceolate, 1–3 mm. long caducous, pubescent at least on the margins; inflorescence 3–6 dm. long, open, branched, with very slender stems, scarcely peduncled, the branches subglabrous, occasionally cinereous-strigulose; hypanthium funnelform, 2 mm. long, with dense white curly pubescence within; sepals lance-

linear, 7–10 mm. long, separate in anthesis; petals white, turning red, ca. 8 mm. long, broadly elliptic, abruptly narrowed into slender claw ca. 2 mm. long; stamens subequal, filaments 8–9 mm. long, slightly enlarged upward; anthers 2–3 mm. long, red; style slightly exceeding stamens, pubescent at base; stigma-lobes ca. 0.3 mm. long; capsule usually finely puberulent, sometimes subglabrous, the body oblong, wing-angled, somewhat narrowed toward summit, 7–9 mm. long, 2–3 mm. wide, rather abruptly narrowed into a very slender stipe-like base 3–6 mm. long.

KEY TO VARIETIES

Hypanthium and sepals cinereous-strigulose.
Ovary cinereous-strigulose; leaves canescent-villous. Kansas to Texas
13a. G. villosa var. typica
Ovary quite glabrous except for few hairs near the summit. So. Texas
Hypanthium, sepals and ovary with short spreading hairs.
Hairs of hypanthium, etc. not gland-tipped. So. Texas
Hairs of hypanthium, etc. gland-tipped. Western Texas & E. New Mex
13d. G. villosa var. arenicola

13a. Gaura villosa Torr. var. typica n.var.

G. villosa Torr., Ann. Lyc. N. Y. 2: 200. 1828. G. cinerea Woot. & Standl., Contr. U. S. Nat. Herb. 16: 152. 1913.

Leaves canescent-villous, the lower lanceolate to spatulate, 8-15 mm. wide, the upper 3-5 mm. wide; hypanthium, sepals, ovaries cinereous-strigose.

Type locality, "Sources of the Canadian," the original collection by James. Range New Mex. and Kans to Texas. Representative material, NEW MEXICO: 20 miles south of Roswell, Chaves Co., F. S. & E. S. Earle 533, type coll., cinerea (NY, US); Santa Rosa, Guadalupe Co., Degener 4803 (NY); sources of the Canadian, James, type villosa (NY). KANSAS: Morton Co., Hitchcock 172 (G, NY, US); Arkalon, Seward Co., Smyth 157 (NY, US); Coldwater, Comanche Co., Rydberg & Imler 678 (NY); Meade, Meade Co., Smyth in 1890 (NY). OKLAHOMA: False Washita, bet. Ft. Cobb & Ft. Arbuckle, Palmer 137 (NY, US); Alva, Woods Co., Stevens 773 (G, NY, US); Clinton, Custer Co., Palmer 12549 (G, NY, US); Bridgeport, Caddo Co., Munz 13576 (P). TEXAS: Seymour, Baylor Co., Reverchon 10 (G, NY); Estelline, Hall Co., Reverchon 4306 (G, P, US); Posey Canyon, Lubbock Co., Demaree 7767 (G); 16 miles no. of Matador, Motley Co., Cory 16046 (P); near Wellington, Collingsworth Co., Cory 16144 (P).

13b. G. villosa Torr. var. McKelveyae n.var.

Strictly herbaceous; stems decumbent, then ascending, 3-5 dm. long; leaves deeply and regularly sinuate-dentate, oblong-lanceolate to oblanceolate

in outline, sparsely villous, about as wide as in typica, but seeming narrower because of the deeper dentation; hypanthium and sepals cinereous-strigulose; ovary usually glabrous except for a few hairs near the summit. (Planta herbacea; caulibus decumbentibus, tunc ascendentibus, 3-5 dm. longis; foliis sinuato-dentatis, parce villosis; hipantio sepalisque cinereo-strigulosis; ovario plerumque glabro, cum capillis paucis supra.)

Type, near Mathis, San Patricio Co., Texas, April 5, 1931, Susan Delano McKelvey 1718, Gray Herbarium; isotype Pomona 186535. Other material seen, TEXAS: Corpus Christi, Tracy 9273 (G, NY, US); Hidalgo Co., Runyon 153 (US); near Brownsville, Cameron Co., Townsend 32 (US). It is a great pleasure to name this very distinct, more herbaceous, less villous local plant of extreme southern Texas for Mrs. McKelvey, whose collections of Onagraceae from Texas have been of great help to me.

13c. Gaura villosa Torr. var. Parksii n.var.

Leaves densely soft-silky, lanceolate to ovate, the lower 10-25 mm. wide, the upper 5-15 mm. wide; hypanthium, sepals, and ovary with dense grayish short spreading hairs. (Folia sericea, lanceolata aut ovata, infimis 10-25 mm. latis, superioribus 5-15 mm. latis; hipantio, sepalis, et ovario cum capillis curtis et extensis.)

Type, sandy open places, Terrell Hill, near Kaicaster, Wilson Co., Texas, June 24, 1935, P. A. Munz 13334 Pomona College Herbarium 212450; isotypes 212582, 212583, 212449. Other material seen, TEXAS: sandy plains of the Nueces, Wright in 1848 (G); Stonewreath Hills, Lower Rio Grande, Schott (NY); 17 miles so. of San Antonio, Metz 656 (NY); near Devine, Medina Co., Cory 12736 (P); San Ygnacio, Tharp 3622 (US); east of Carrizo Springs, Dimmit Co., Jones 28140 (P).

This interesting variant was first pointed out to me in the field by Mr. H. B. Parks, botanist and entomologist of San Antonio, Texas, and I am very happy to name it for him.

13d. Gaura villosa Torr. var. arenicola n.var.

Leaves densely soft-silky, lanceolate to lance-ovate, 5-10 mm. wide; hypanthium, sepals, and ovary with short spreading gland-tipped hairs. (Folia sericea, lanceolata aut lanceo-ovata, 5-10 mm. lata; hipantio, sepalis et ovario cum capillis curtis, extensis et glandulosis).

Type, five miles northeast of Portales, Roosevelt Co., New Mexico, on sand dunes near Highway 33, June 14, 1930, Goodman & Hitchcock 1124, Pomona College Herbarium No. 171881; isotype at NY. Other material seen, NEW MEXICO: near Portales, Wooton in 1909 (US). TEXAS: sand hills, 2 mi. so. of Muleschoc, Bailey Co., Ferris & Duncan 3421 (NY);

Odessa, Reed 1909 (US); 2 miles west of Bledsoe, Morton Co., Cory 16528 (P) OKLAHOMA: Canadian River Valley, near Pack Saddle Bridge, Ellis Co., Goodman 2591 (P).

14. GAURA FILIPES Spach, Nouv. Ann. Mus. Paris 4: 379. 1835.

Perennial herb, branched from base, 5-18 dm. tall, ascending to erect, the stems puberulent, sometimes also hirsute, reddish, paniculately branched above; basal leaves not seen; cauline leaves numerous, crowded on lower parts of stem, linear to oblanceolate or lanceolate, usually sinuate-denticulate 3-6 cm. long, 3-15 mm. wide, acute to obtuse, narrowed at base, subsessile or short-petioled, subglabrous to strigulose, sometimes villous underneath on veins; upper leaves reduced, 0.5-2 cm. long, lance-linear, acuminate; floral bracts lance-linear, 3-5 mm. long, caducous; inflorescence open-paniculate, 2-5 dm. long, canescent-strigulose especially on the buds, scarcely peduncled or with peduncles 5-10 cm. long, the spikes on very slender axes; hypanthium gray-strigulose without, narrow-funnelform, 3-5 mm. long, white-puberulent within; sepals strigulose, lance-linear, 5-10 mm. long, reflexed separately in anthesis; petals white, turning rose, broadly oblanceolate, clawed, 4-6 mm. long; filaments subequal, slightly enlarged upward, 4-5 mm. long; anthers 1.5-2 mm. long; style pubescent at base, scarcely exceeding stamens; stigmalobes 0.4-0.8 mm. long; capsule strigulose, obovoid-clavate, sharply 4-angled toward the summit, the body 4-5 mm. long, scarcely 2 mm. wide, gradually or rather abruptly narrowed into a very slender pedicel-like base 1-3 mm. long.

KEY TO VARIETIES

Sepals 5-7 mm. long; petals 4-5 mm. long	a. G	. filipes var. typica
Sepals 8-10 mm. long; petals 6 mm. long	b. <i>G</i>	filipes var. major

14a. Gaura filipes Spach var. typica n.var.

G. filipes Spach, Nouv. Ann. Mus. Paris 4: 379. 1835. Flowers small; sepals 5-8 mm. long; petals 4-5 mm. long.

Type locality, Jacksonville, Fla. Range from So. Car. to Fla. Representative material, SOUTH CAROLINA: 25 miles west of Columbia, Lexington Co., Munz 13359 (P); Aiken, Ravenel (NY, US); Clemson College, House 2894 (US). GEORGIA: Cobb Co., Wilson in 1900 (G, NY, US); Hogansville, Troup Co., Wiegand & Manning 2166 (G). ALABAMA: Auburn, Lee Co., Earle & Baker 1230 (NY, P); Mobile, Mohr (G). MISSISSIPPI: Meridian, Schuchert in 1896 (US). FLORIDA: Aspalaga, Curtiss 3929c (G, NY, US); River Junction, Gadsden Co., Nash 2578 (G, NY, US); Jacksonville, Drummond, apparently type coll. (G, K, photo at P); Lake City, Nash 2498 (US).

14b. GAURA FILIPES Spach var. MAJOR Torr. & Gray, Fl. N. Am. 1: 517. 1840. G. Michauxii Spach, Nouv. Ann. Mus. Paris 4: 379. 1835. Flowers larger, the sepals 8-10 mm. long; the petals 6 mm. long.

Type locality, Kentucky, if we use as type the first specimen cited which was collected by Short. Specimens seen, INDIANA: 1 mi. west of Plainsville, Daviess Co., Deam 47902 (G, US). TENNESSEE: Lookout Mt., Biltmore Herb. 3929b (G, NY, US); Cowan, Franklin Co., Biltmore Herb. 3929a (G, NY, US). KENTUCKY: Barrens of Ky, Short, type (NY). Without definite locality, "Chez les Cherokees, Palisot de Beauvois, type Michauxii (Del, photo at P). Material from Jackson Co., Fla., Chapman (NY) is quite intermediate in flower size with var. typica. A peculiar specimen ("On shell islands near Gulf," La., Langlois 97 (NY) has capsule and stipe of G. filipes and flower-size of G. Lindheimeri; it may possibly be a hybrid of Lindheimeri and some other.

15. GAURA NEALLEYI Coulter, Contrib. U. S. Nat. Herb. 1:38. 1890.

Apparently mostly biennial from a fleshy tap root, usually several-stemmed from base, sometimes simple; stems hirsute below, mostly simple, ascending to erect, 2-6 dm. high; basal leaves oblanceolate, sinuate-dentate, 5-15 cm. long, 8-18 mm. wide, quite glabrous except for the short stiff hairs on margins and beneath the midrib, narrowed gradually into a winged petiole; lower cauline leaves rather crowded, lanceolate, almost sessile, sinuate-dentate, acute, with pubescence of basal leaves, mostly 1.5-3 cm. long, 5-10 mm. wide; uppermost reduced and almost linear; floral bracts rounded-ovate, ciliate, 2.5-3.5 mm. long, caducous; inflorescence rather few-flowered, lax spicate, scarcely or short-peduncled, becoming 1-3 dm. long in fruit, subglabrous in lower parts, glandular-puberulent in upper parts and on hypanthium and calvx and ovary; hypanthium 8-12 mm. long, puberulent within; sepals 8-11 mm. long, reflexed separately in anthesis; petals whitish, aging red, broadly oblanceolate, 4-5 mm. long; stamens subequal; filaments 4-5 mm. long, somewhat flattened; anthers 2-3 mm. long; style exceeding stamens, puberulent at base; stigma-lobes ca. 0.6 mm. long: capsules ovoid-pyramidal, 8-9 mm. long, 2.5-3 mm. wide, rather sharply 4-angled, glabrous, each face with midrib and minute transverse wrinkles, the base abruptly narrowed into a thick stipe-like base 1-1.5 mm. long.

Type locality, Chenate Mts., Presidio Co., Texas. Range, western Texas and adjacent New Mexico. Material seen, TEXAS: Limpia Canyon, 12 mi. north of Ft. Davis, Jeff Davis Co., Cory 9659 (P), Limpia Canyon, Tracy 294 (G, NY), Limpai Creek, Earle & Tracy 294a (NY, US); Davis Mts., Earle & Tracy in 1902 (NY); Old Ft. Davis, Ferris & Duncan 2718

(NY); Cibolo, Havard in 1881 (US); Chenates region, Nealley in 1889, type (US); Kokernot Springs, near Alpine, Brewster Co., Cory 9632 (P). NEW MEXICO: Dark Canyon, Guadalupe Mts., Standley 40666 (US); Copper Mines, Wright in 1851 (NY); El Capitan Mts., Lincoln Co., F. S. & E. S. Earle 517 (NY, US).

This species is characterized by its hirsute stem, glandular inflorescence, and short stipe. It intergrades with G. gracilis f. glandulosa from which it is doubtfully distinct. For example, of the specimens above cited, Cory 9632 approaches the latter in its very short stipe; Long 7437 (US) from Sandia Mts., New Mex. has the short stipe of gracilis but the flowers of Nealleyi. Nelson 3913 (US) from La Ventura, Coahuila has the flower size of Nealleyi but the strigulose fruit of typical gracilis.

16. GAURA SINUATA Nutt., ex Seringe, in DC., Prodr. 3: 44. 1828.

Perennial herb, 3-8 dm. tall, the stem simple or more generally with several ascending branches from above the base, glabrous or nearly so; basal leaves oblanceolate to oblong-lanceolate, subglabrous, or puberulent especially on the edges, 3-8 cm. long, 1-2 cm. wide, sinuate-dentate, obtuse to acute, with short winged petioles; cauline leaves rather crowded, spatulate to lanceolate, even linear, sinuate-dentate to almost entire, often wavy, subglabrous to strigulose, 1-5 cm. long; floral bracts 1-3 mm. long, caducous, lanceolate to ovate with narrow tip, subglabrous or with few short hairs on margins; inflorescence simple or branched, 2-5 dm. long, with naked peduncles 1 or more dm. long; hypanthium 2.5-3 mm. long, subglabrous or sparsely strigulose, narrow-funnelform, white-pubescent within; sepals grayish-strigulose, 7-10 mm. long, narrow, separately reflexed in anthesis; petals white, becoming red, 8-10 mm. long, broadly elliptic, the claw rather narrow, ca. 2 mm. long; filaments subequal, slightly enlarged upward, 8-10 mm. long; anthers reddish 3-3.5 mm. long; style somewhat longer than stamens, puberulent at very base; stigma-lobes about 0.5 mm. long; capsule nearly or quite glabrous, the body fusiform, obtusely 4-angled, 5-9 mm. long, 1-1.5 mm. wide, gradually tapering into rather thick pedicel-like base 2-5 mm. long.

Type locality, "In Arkanza et Red-River," probably in Okla. Ranging from Okla. to northern Mexico. Representative material, Arkansas & Red River, Nuttall in 1825, type coll. (Del), Arkansa, Nuttall (Kew, photo at P); Red River, Nuttall (NY). OKLAHOMA: Mountain Park, Kiowa Co., Stevens 1218 (G, P); Granite, Greer Co., Stevens 999 (G, NY, US); Mannsville, Johnston Co., Griffith 3491 (G, NY); Norman, Cleveland Co., Middleton in 1935 (P). TEXAS: Texas III, Drummond 76 (G, NY); Chillicothe, Wilbarger Co., Ball 961 (NY, US); Ft. Worth, Ruth 37 (G, NY, US); Dallas, Reverchon, Curtiss distrib. 896 (G, NY); Mertzon, Irion Co., Palmer 12415 (G, NY, US); Comanche Spring, Lindheimer 800 (G, US);

Kerrville, Kerr Co., Heller 1692 (G, NY, US); New Braunfels, Lindheimer 802 (G, NY, US); New Hempstead, Waller Co., Hall 214 (G, NY, P); Carrizo Spring, Dimmit Co., Jones 28145 (P); Refugio, Refugio Co., Benke 5401 (P); Limpio, Wright in 1851 (G); Kingsville, Kleberg Co., Tracy 9275 (NY, US); Diversion Lake, Archer Co., Cory 13222 (P). COAHUILA: Diaz, Pringle 8320 (G, NY, P. US); Saltillo, Palmer 233 (G, NY, P, US); Sabinas, Nelson 6810 (US). TAMAULIPAS: Cerro del Chino, Sierra de San Carlos, Bartlett 10717 (US).

This species is characterized by its slender, pedicelled glabrous fruit. It is becoming naturalized out of its original range, as for example, So. Car., Charleston, *Robinson 196* (G); Tuscaloosa, Ala., *Harper 3192* (NY, US); San Dimas, Los Angeles Co., California, *Wheeler 947* (P); junction Los Troncos and San Francisco Creeks, San Mateo Co., Calif. *Abrams 13687* (P).

17. GAURA ODORATA Sessé ex Lagasca, Gen. et Spec. Pl., 14. 1816.

Schizocarya Drummondii Spach, Nouv. Ann. Mus. Paris IV, 3: 382. 1835. Gaura Drummondii T. & G., Fl. N. Am. 1: 519. 1840; D. Dietr., Syn. Pl., 1297. 1840. G. hispida Benth., Pl. Hartweg., 288. 1840.

Apparently biennial or winter annual, mostly branched at base, the stems ascending, 2–5 dm. high, rather slender, simple or few-branched, grayish pubescent, the hair appressed or spreading but usually not over 1 mm. long; basal leaves apparently oblanceolate, sinuate-dentate; lower stem leaves lanceolate to ovate or oblanceolate, 2–5 cm. long, 5–15 mm. wide, sinuate-dentate, acutish at both ends, scarcely petioled, rather crowded, gradually reduced upward and becoming lance-linear, strigulose; floral bracts lance-ovate, acute, 3–6 mm. long, strigulose, caducous; spikes sessile or short-pedunculate, with nodding tips, 1–3 dm. long in fruit, mostly strigulose; petals oblong-lanceolate, 8 mm. long, white to pink, turning red; stamens subequal, filaments flattened, 5–6 mm. long; anthers reddish, ca. 4 mm. long; style well exserted beyond stamens, pubescent at base; stigma-lobes ca. 1 mm. long; capsule glabrous to strigulose, 8–11 mm. long, the lower third terete, gradually enlarged upward, the upper two-thirds ovoid-pyramidal, acute, rather sharply 4-angled, each face ca. 2.5 mm. wide, with median nerve; seeds up to 4.

Type locality, "Habiat in Nova Hispania." Ranging from Texas to central Mexico. Representative material, TEXAS: Ft. Worth, Ruth 276 (NY); Comanche Spring, Lindheimer 41 (G); Temple, Bell Co., Wolff 3016 (US); San Felipe de Austin, Drummond 36, type coll. Drummondii (G, NY, K, photo at P); Austin, Hall 213 (G, NY, P, US); near Roosevelt, Kimble Co., Cory 18969 (P); San Antonio, Heller 1590 (G, NY, US); Bracken, Bexar Co., Groth 146 (G, NY, US); Uvalde, Palmer 13530 (US); San Diego, Duval Co., Croft 111 (NY). TAMAULIPAS: Matamoros,

Berlandier 2313 (G). NUEVO LEON: Monterey, Dodge 110 (US). COA-HUILA: Saltillo, Palmer 23 (G, NY, US); DURANGO: Durango, Palmer 94 (G, NY, US). GUANAJUATO: Leon, Hartweg 1603, type hispida (K, photo at P). SAN LUIS POTOSI: Guascama, Purpus 5383 (G, NY, US). MICHOACÁN: Morelia, Arsène 2752 (G, US). QUERÉTARO: Querétaro, Arsène 10599 (G,US). HIDALGO: Ixmiquilpan, Rose, Painter and Rose 9079 (G, US). PUEBLA: San Luis Tultitlanapa, Purpus 3387 (G, NY, US). OAXACA: Distr. Etla, Seler 83 (G, US); Huitzo, Rose & Rose 11364 (G, NY, US). Without locality, "G. odorata Lag., Hort. veg. Matrit 1814? Reuter (Boissier)."

I am unable to separate plants with hirsute stems from those without; nor can I find any other definite characters by which *G. hispida*, for instance, can be segregated from the other material. Plants from the more southern and western parts of the range seem to have more pubescence on the fruits than do others. The species is with some difficulty separable from all forms of *G. coccinea*, which also has the thick base to the fruit, but I believe the larger flowers and more early shedding of the floral bracts, as well as usually longer fruits generally distinguish the two.

18. GAURA COCCINEA Nutt. ex Fraser's Cat., 1813 as nomen nudum; ex Pursh, Fl. Sept. Am. 2: 733. 1816; Nutt., Gen Am. 1: 249. 1818.

Perennial herb; stems several, simple or branched, ascending, 1-5 dm. high glabrous to strigose and hirsute; leaves numerous, mostly sessile, the lower oblanceolate to broadly or narrowly lanceolate or oblong, 1.5-3.5 cm. long; main ones oblong-lanceolate to almost linear; uppermost linear to lancelinear; leaves canescent to glabrous; floral bracts linear to lanceolate, 3-6 (11) mm. long, persistent; spikes simple, sessile or short-peduncled, becoming 5-18 cm. long, nodding at tips; hypanthium narrow-infundibuliform, 5-8 mm. long, strigulose without, puberulent within; sepals oblong-linear separately reflexed in anthesis, 5-8 mm. long; petals whitish to pink or red, aging red, 3-6 mm. long, broadly elliptic with narrow claw; stamens subequal; filaments 4-5 mm. long, white to yellowish, somewhat flattened upward; anthers yellow or red, 2-5 mm. long; style slightly exceeding stamens, pubescent at base; stigma-lobes suborbicular, ca. 0.25 mm. long; capsule 5-10 mm. long, 1.5-3 mm. thick, sessile, the body proper 4-angled. tapering toward the tip in pyramidal fashion, abruptly constricted toward the gradually narrowed but stout terete base.

KEY TO VARIETIES

Capsule 5-7 mm. long, 2.5-3 mm. wide; anthers 2-3 mm. long. Stem and leaves more or less pubescent.

Leaves (at least the lower) lanceolate and sinuate-dentate.

Main leaves mostly plane, oblong, crowded; flowers crowded; inflorescence not peduncled; plant 1-3 dm. high. Ariz. and New Mex. northward.....18a. G. coccinea var. typica

18a. Gaura coccinea Nutt. var. typica n.nom.

G. coccinea Nutt. ex Pursh, Fl. Sept. Am. 2: 733, 1816. G. multicaulis Raf., Atlantl. Journ., 146. 1832 new name for coccinea. G. marginata Lehm., in Hook., Fl. Bor. Am. 1: 208. 1834. G. coccinea var. integerrima Torr., Ann. Lyc. N. Y., 2: 200. 1828. G. Roemeriana Scheele, Linnaea 21: 579. 1848.

Stems can escent-strigose, mostly 1-3 dm. high, more or less hirsute; leaves can escent, oblong to lanceolate, 4-8 mm. wide (the upper narrower), repanddentate to entire, 1-3.5 cm. long; spikes mostly dense not more than 1 dm. long, usually not peduncled.

Type locality, "from the Missourie." Ranging widely from Alberta and Manitoba to eastern Calif., Ariz. and Texas. Representative material, ASSINIBOIA: Regina, Fowler in 1903 (US). ALBERTA: Rosedale, Moodie 1024 (G, NY, US); Medicine Hat, Macoun 4937 (G). SASKAT-CHEWAN: Moose Jaw, Johnson in 1905 (NY). MINNESOTA: Lake Traverse, Traverse Co., Sheldon in 1893 (G, NY, US). NORTH DAKOTA: Leeds, Benton Co., Lunelli in 1910 (NY, US); Mandan, Sarvis 22 (US). SOUTH DAKOTA: Deadwood, Carr 51 (G, NY, US); Jamesville, Bruce in 1899 (US). MONTANA: Pony, Madison Co., Rydberg & Bessey 4589 (G, NY, US); Great Falls, Wilcox 16 (NY); Helena, Kelsey in 1891 (P). WYOMING: Buffalo, Johnson Co., Tweedy 3621 (NY); Dayton, Sheridan Co., Tweedy 2604 (NY). UTAH: Towner's Ranch, Purpus 6161 (P). NEVADA: Las Vegas, Clark Co., Rydberg 6255 (NY); Indian Spring, Jones in 1906 (P). CALIFORNIA: Providence Mts., e. San Bernardino Co., Munz, Johnston & Harwood 4058 (P, US); Barnwell, Munz 13837 (P). ARIZONA: Williams, Toumey 160 (US); Flagstaff, MacDougal 205 (G, NY, US); Peach Springs, Wilson in 1893 (NY, US); Ft. Huachuca, Wilcox in 1891 (US). COLORADO: Ft. Collins, Crandall in 1896 (NY); Galeton, Weld Co., Johnston 1017 (P); Sterling, Logan Co., Mathias 335 (P); Denver, Clokey 2779 (NY); Pueblo, Baker, Earle & Tracy 9 (NY, P, US); Buena Vista, Chaffee Co., Keck 848 (P); Silverton, Tweedy 110 (US). KANSAS: Logan Co., Hitchcock 171 (G. NY, US); Johnson, Stanton Co., Thompson 70 (G, NY, US); Dodge City, Ellis in 1891 (NY, US). NE-BRASKA: Thedford, Thomas Co., Rydberg 1343 (NY, US); Broken Bow, Webber in 1889 (NY, US); Ogalalla, Jones in 1925 (P). MISSOURI: Watson, Atchison Co., Bush 333 (G, NY, US); Atherton, Jackson Co., Bush 7977 (NY). OKLAHOMA: Cherokee, Alfalfa Co., Stevens 647 (G, NY, US); Huntsville, Kingfisher Co., Blankinship in 1896 (G, US). NEW MEXICO: sources of the Canadian, James, type of var. integerrima (NY); Las Vegas, Arsène 18788 (P); Sandia Mts., Sandoval Co., Ellis 117 (NY, US); Datil, Catron Co., Eggleston 20345 (NY, US); Silver City, Grant Co., Eastwood 8442 (G). TEXAS: Limpia Canyon, Davis Mts., Tracy & Earle 295 (G, NY, US); Cienega Mt., Brewster Co., Cory 2147 (P); Del Rio, ValVerde Co., Palmer 11351 (G, NY, US); Neubraunfels, Roemer, Prager Herb. (Calif. Acad.) type coll. Roemeriana. It has been naturalized in various places outside its native range: Bingen, Wash., Suksdorf in 1903 (NY); Brea, Orange Co., Calif., Wolf 3809 (NY); Idaville, White Co., Ind., Deam 48855 (G); Rochester, Mich., Farwell 7017 (G); Rochester, N.Y. Baxter 1007 (G); Porto Alegro, Rio Grande do Sul, Brazil, Reinick in 1899 (G).

18b. Gaura coccinea Nutt. var. epilobioides (HBK) n.comb.

G. epilobioides HBK., Nov. Gen. et Sp. 6: 93. 1823. Schizocarya Kunthii Spach, Nouv. Ann. Mus. Paris 4: 383. 1835 new name for epilobioides. G. sinuata Moc. & Sessé ex Ser., in DC., Prodr. 3: 45. 1828, as syn. G. spicata Moc. & Sessé ex Ser., l.c. in syn.; Moc. & Sessé, Pl. N. Hispan. ed. 1, 55. 1887-90. G. suffrutescens Moc. & Sessé, ex Ser., l.c. G. bracteata Moc. & Sessé ex Ser., l.c. Schizocarya crispa Spach, l.c., 384. Gaura crispa D. Dietr., Syn. Pl., 1298, 1840.

Stems mostly 3-4 dm. long, mostly cinereous-stringose; leaves not crowded, mostly acute to acuminate, cincereous, 1-3 cm. long, 1.5-4 mm. wide, wavy; spikes 1-2.5 dm. long, lax, often on peduncles up to 4 cm. long.

Type locality, Actopán, Hidalgo, Mexico. Ranging from Arizona and Texas to south central Mexico. Representative material, ARIZONA: Kingman, Mohave Co., Kearney & Peebles 12591 (Sacaton); Congress Jct., Yavapai Co., Jones in 1903 (P, US); 12 mi. no. of White River, Navajo Co., Goodman & Hitchcock 1303 (NY, P); Santa Rita Mts., Pringle 16 (G); Ft. Huachuca, Palmer 417 (G, US). NEW MEXICO: Carlsbad Cavern, Standley 40429 (US). TEXAS: Chisos Mts., Mueller 8105 (G, NY); Chenati Mts., Presidio Co., Nealley 156 (NY, US); Alpine, Hughes 31 (NY); San Antonio, Jermy (G, NY, US). CHIHUAHUA: Chihuahua, Palmer 369 (G, NY, US). COAHUILA: Saltillo, Palmer 24, (G, NY, US); DURANGO: Tepehuanes, Palmer 275 (G, NY, US). VERA CRUZ: Orizaba, Botteri 915 (G). NUEVO LEON: Bawes, C. H. & M. T. Mueller 218 (P). ZACATECAS: Concepción del Oro, Palmer 308 (G, US). SAN LUIS POTOSI: San Luis Potosi, Parry & Palmer 255 (G, US). HIDALGO: Actopán, Humboldt, type coll (Ber, photo at P; apparently

same at Paris); Pachuca, Rose Painter & Rose, 8820 (NY, US). MEXICO: Jacaboys, Pringle 10397 (G, US); San Angel, drawing of G. sinuata fl. mex., G. bracteata Ser. (Del, G, P); PUEBLA: Tehuacán, Seler 8 (G). Without locality, G.? suffrutescens Sessé & Mociño, pl. Geneva (Del, tracing G, P); G. sinuata, Sessé, Mociño, Castillo & Maldonado 5148 & 938 (Madria).

More southern, taller, more lax, with leaves less crowded and more wavy than in var. typica, but intergrading freely with it; for example, Flagstaff, Ariz., Munz 13001 (P); Oracle, Ariz., Jones in 1903 (P); Sonoita, Loomis & Peebles 5351A (Sacaton, US); Bill Bunton's Ranch, Presidio Co., Texas, Cory 2141 (P); Kiowa Creek, Sterling Co., Texas, Cory 584 (P); Parras, Coahuila, Gregg in 1847 (G, NY).

18c. Gaura coccinea Nutt. var. parvifolia (Torr.) T. & G., Fl. N. Am. 1: 518. 1840.

G. parvifolia Torr., Ann. Lyc. N.Y. 2: 201. 1828. G. linearis Woot. & Standl. Contr. U. S. Nat. Herb. 16: 154. 1913.

Branches and leaves subglabrous to pubescent; leaves quite linear, entire mostly 5-15 mm. long, 1-2 mm. wide.

Type locality, "On the Canadian." Ranging from Kansas and Colorado to northern Mexico. Representative material, KANSAS: Kandrado, Smyth 459 (NY); Goodland, Smyth in 1892 (NY); Tribune, Greeley Co., Reed in 1892 (P). COLORADO: Pueblo, Popenoe in 1878 (P); NEW MEXICO: On the Canadian James, type (NY); Tularosa Creek, Otero Co., Wooton in 1897 (G, US); Albuquerque, Jones 4120 (P); Lakewood, Wooton in 1909, type linearis (US); Silver City, Grant Co., Wolf 2625 (G, P). ARIZONA: Cottonwood, Rothrock 349 (G, US); Elgin, So. Ariz., Peebles, Harrison & Kearney 3363 (Sacaton); Ft. Huachuca, Wilcox in 1894 (US). TEXAS: Culberson Co., Cory 2142 (P); Red River above Burkburnett, Tharp 524 (NY); Vernon, Reverchron 3846 (G, US). CHI-HUAHUA: San Pedro, Sierra Madre, Jones in 1903 (P); Casas Grandes, Nelson 6336 (US). ZACATECAS: Concepción del Oro, E. Palmer 318 (NY).

Intergrading freely with var. typica, as for example, Trail Glen, Colo., Clements 45 (G, NY); Durango, Colo., Tweedy 440 (NY, US); Alpine, Texas, Cory 9281 (P), Palmer 34029a (NY); Las Vegas, New Mex., Arsène 18363 (P); Ft. Bayard, New Mex., Mulford 570 (NY); so. of Raton, N. M., Mathias 539 (P). Smoother plants intergrade with var. glabra: Santa Fé, New Mex., Bertrand 66 (US); Dulca, Jicarilla Apache Reservation, Standley 8165 (US); San Ysidro, Arsène 19012 (US); Ute Park, Colfax Co., New Mex., Standley 13866 (US); Seward Co., Kansas, Carleton 334

(US); Huachuca Mts., Ariz., Holzner 1568 (US); San Francisco Mts., Knowlton 175 (US).

18d. GAURA COCCINEA Nutt. var. GLABRA (Lehm.) Torr. & Gray, Fl. N. Am. 1: 518. 1840.

G. glabra Lehm. in Hook., Fl. Bor. Am. 1: 209. 1834. G. induta Woot. & Standl., Contrib. U. S. Nat. Herb. 16: 153. 1913.

Plant nearly or quite glabrous on stems and leaves; leaves as in var. typica, but more wavy; hypanthium strigulose.

Type locality, "About Carlton-House, on the Saskatchawan." With much the same range as var. typica and in some regions (Wyo. & Colo.) seemingly more abundant than that variety; perhaps this should be rated as only a form, since its glabrous condition is its chief character, but its tendency toward more wavy leaves may argue for varietal recognition. Material from northeastern New Mexico and eastern Colorado tends to have narrow leaves and is Wooton and Standley's induta; it is somewhat intermediate with var. parvifolia. Plants from Wyoming and Montana have very blunt and short lower leaves; but intermediate material between these extremes and the usual form is more abundant than any of the extremes themselves. Representative material may be cited as follows, NEBRASKA: Kimball, Moldenke 7232 (NY). KANSAS: Tribune, Greeley Co., Reed in 1892 (P); Liberal, Seward Co., Rydberg & Imler 868 (NY). MONTANA: Ravalli, Jones in 1909 (P); Custer, Yellowstone Co., Lloyd in 1893 (NY); Pony, Madison Co., Rydberg & Bessey 4590 (NY). SOUTH DAKOTA: Ft. Pierce, Harper in 1891 (P); Hot Springs, Fall River Co., Rydberg 709 (NY, US). WYOMING: Buffalo, Sheridan Co., Tweedy 3620 (NY); Platte Hills, Nelson 392 (G); Sybille, Albany Co., Nelson 7412 (G, NY, P, US); Granger, Sweetwater Co., Jones in 1896 (P), Merrill & Wilcox 787 (NY, US). COLORADO: Livermore, Larimer Co., Munz 11124 (P); New Windsor, Weld Co., Osterhout in 1901 (NY, P); Denver, Jones 657 (P, US); Gunnison, Baker 456 (G, NY, P, US); Trinidad, Mulford 10 (NY). UTAH: St. George, Washington Co., Jones 5110 (P, US); San Juan River, Eastwood 30 (G, US). NEVADA: Las Vegas, Craig 1392 (P), Goodding 2303 (G, NY). CALIFORNIA: Clark Mt., eastern Mohave Desert, Munz 12857 (P). ARIZONA: Prescott, Wolf 2348 (G); Hackberry, Mohave Co., Jones 4475 (G, NY, P in part, US); Rye, Gila Co., Jones in 1890 (P); Ft. Huachuca, Palmer 420 (US). NEW MEXICO: Santa Fe, A. A. & E. G. Heller 3659 (G, NY, P); White Mts., Lincoln Co., Wooton 186 (G, P); Pecos, San Miguel Co., Standley 4933, type coll. induta (G, NY, US); Farmington, San Juan Co., Standley 6919 (US). OKLAHOMA:

Alva, Woods Co., Stevens 658 (NY, US). TEXAS: El Solitario, Brewster Co., Cory 2140 (P); near Kirkland, Hardeman Co., Cory 13366 (P).

18e. Gaura coccinea Nutt. var. arizonica n. var.

Stems several, 3–6 dm. high, branched, canescent-strigulose, densely leafy; main leaves lanceolate to lance-ovate, wavy, 2–5 cm. long, 3–8 mm. wide; floral bracts lance-linear, 4–12 mm. long; spikes 3 dm. long in fruit; hypanthium cinereous-strigulose, narrow, 6–7 (10) mm. long; sepals cinereous-strigulose, 9–10 mm. long; petals 6 mm. long; anthers 4–5 mm. long; capsule usually cinereous-strigulose, ca. 1 cm. long, 1.5–2 mm. wide, thickest at about the middle, with a rather long-acuminate beak. (Caules 3–6 dm. alti, canescento-strigulosi; foliis lanceolatis aut lanceo-ovatis, undulatis, 2–5 cm. longis; hipantio cinereo-striguloso, angusto, 6–7 (10) mm. longo; sepalis cinereo-strigulosis, 9–10 mm. longis; petalis 6 mm. longis; antheris 4–5 mm. longis; capsulis 1 cm. longis, 1.5–2 mm. latis, rostratis, cinereo-strigulosis).

Type, Globe, Arizona, Eastwood 8657, May 17, 1919, Gray Herbarium. Other material seen, ARIZONA: Globe, Kearney & Peebles 9263 (Sacaton, US), 9262 (Sacaton, US); Marana, Pima Co., Harrison & Fulton 6817 (Sacaton); between Casa Grande & Tucson, Harrison 6817 (US); Marana, Loomis & Peebles (Sacaton); Prescott, Peebles, Harrison & Kearney 4288 (Sacaton); Mesa near Rock & Rye Creeks, Gila Co., Collom 86a (US). NEW MEXICO: Gallinas River, Eggleston 5973 (US). COAHUILA: Carneros Pass, Pringlw 3105 (NY, US in part).

Characterized by its long anthers and long narrow capsules, this variety might almost seem to be worthy of specific recognition and it was in that fashion that I first treated it. But it does intergrade with G. coccinea var. glabra, for example, Kearney & Peebles 9263 above cited, also Toumey 144 from Hot Springs, Ariz (US).

UNCERTAIN OR EXCLUDED NAMES

Gaura Chinensis Lour., Fl. Cochin., 225 1790. The sessile stigma, erect petals and other characters mentioned in Loureiro's description would exclude this yellow-flowered plant from *Gaura*. At the present writing I do not have access to literature on Chinese Botany and do not know what disposition has been made of this name.

Gaura Epilobia Moc. & Sesse, ex Ser., in DC., Prodr. 3: 45. 1828 is Oenothera (Hartmannia) rosea Ait., Hort. Kew. ed. 1, 2: 3. 1789.

GAURA? FRUTICULOSA Benth., Voy. Sulph., 15. 1844 is Gonglyocarpus fruticulosus Brandg., Proc. Calif. Acad. II, 2: 158. 1889.

GAURA FRUTICOSA Loefl., Iter Hispan., 248. 1758 is Combretum fruticosum Stuntz, U. S. Dept. Agric., Bur. Pl. Ind., Invent. Seeds & Pl. Import. No. 31: 86. 1914.

Explanation of figures

(This plate is made to illustrate the shapes of the fruits of the various species of *Gaura*. In order to avoid confusion, no shading nor pubescence is indicated). All specimens indicated are in Pomona College Herbarium.)

- Fig. 1. Gaura mutabilis Cav. Fruit 9 mm. long; Colonia Juarez, Mex., Jones in
- 1903.

 Fig. 2. Guara parviflora Dougl. var. sypica. Fruit 8 mm. long; Shawmut, Mont., C. L. Hitchcock 2441.
- Fig. 3. Gaura biennis L. var. typica. Fruit 6.5 mm. long; Philadelphia, Penn., G. Watson.
- Fig. 4. Gaura neomexicana Woot. var. typica. Fruit 8 mm. long; Tularosa Creek, Otero Co., New Mex., Wolf 2768.
- Fig. 5. Guara macrocarpa Rothrock. Fruit 14 mm. long; Jeff Davis Co., Tex., Cory 2137.
- Fig. 6. Gaura Lindheimeri Engelm. & Gray, Fruit 9 mm. long; Houston, Tex.,
- Munz 13339.

 Fig. 7. Gaura angustifolia Michx. var. typica. Fruit 8 mm. long; Ortega, Fla.
- O'Neill 1011.

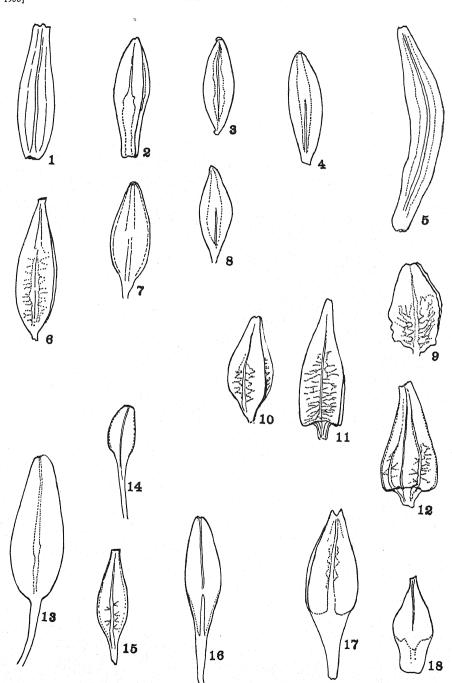
 Fig. 8. Gaura filformis Small var. typica. Fruit 6 mm. long; Dickenson, Galveston
 Co. Tax. Card 11308
- Co., Tex., Cory 11398.

 Fig. 9. Gaura suffulta Engelm. var. typica. Fruit 6 mm. long; Live Oak Creek,

 Creekett Co. Tex. Cory in 1936
- Crockett Co., Tex., Cory in 1936.

 Fig. 10. Gaura gracilis Woot. & Standl. var. typica. Fruit 7 mm. long; Black
- Range, New Mex., Metcalfe 1033.

 Fig. 11. Gaura brachycarpa Small. Fruit 9 mm. long; Sabinal, Tex., Jones 29570.
- Fig. 12. Gaura tripetala Cav. var. typica. Fruit 8 mm. long; Hempstead, Tex., E. Hall 211.
- Fig. 13. Gaura villosa Torr. var. typica. Fruit 13 mm. long; near Romero, Hartley Co., Tex., Cory 16424.
- Fig. 14. Gaura filipes Spach. var. typica. Fruit 8 mm. long; Auburn, Ala., Earle & Baker in 1897.
- Fig. 15. Gaura Nealleyi Coulter. Fruit 8 mm. long; Limpio Canyon, Tex., Cory 9659.
- Fig. 16. Gaura sinuata Nutt. Fruit 10 mm. long; Diversion Lake, Archer Co., Tex., Cory 13222.
 - Fig. 17. Gaura odorata Sesse. Fruit 10 mm. long; Austin, Texas, E. Hall 213.
- Fig. 18. Gaura coccinea Nutt. var. typica. Fruit 7 mm. long; Big Lake, Reagan Co., Tex., Cory 585.



Figures 1-18. Explanation on opposite page

Guara Heterandra Torr., Pacif. RR. Rept. 4: 87. 1857 is Heterogaura heterandra Cov., Contr. U. S. Nat-Herb. 4: 106. 1893.

GAURA HIRSUTA Scheele, Linnaea 21: 580, 1848. I am uncertain from the description as to application of this name and have been unable to locate the type on which it is based. It may well be G. Lindheimeri.

GAURA HUMILIS D. Dietr. Syn. Pl. 2: 1297. 1840 is Gayophytum humile Juss., Ann. Sci. Nat. ser. 1, 25:18. 1832.

GAURA LAXA Loefl., Iter Hispan., 248. 1758 is Combretum Loeflingii Eichl., in Mart., Fl. Bras. xiv, 2: 110 according to Index Kewensis.

GUARA LEUCOCARPA Comien, ex Steud., Nom., ed. 2, 1: 666. 1840, nomen nudum.

GAURA LINIFOLIA Nutt., ex James, Exped. Rocky Mts., 2: 355, 1823 is Stenosiphon linifolium Britton, Mem. Torrey Club 5: 236. 1894.

GAURA UNDULATA Desf., Tableau de l'Ecole de Bot., ed. 2, 196. 1815, nomen nudum.

Pomona College, Claremont, California

Effect of artifical wind on growth and transpiration in the Italian millet, Setaria italica

V. Panduranga Rao (with one figure)

Wind is one of the potent environmental factors that affect vegetation. Notwithstanding its importance, the literature upon this subject is meager and is largely confined to non-agricultural plants, sugar cane and orchard trees being the chief exceptions. The problem is especially important in those parts of India where moderate to strong winds prevail during the growing period and occasionally contribute to widespread destruction of crops.

The great importance of *Setaria italica* as a food crop for the poorer classes in these semiarid regions makes its behavior toward wind especially interesting.

MATERIAL AND METHODS

Strain No. K. 23 of *Setaria italica* Beauv., developed at the Dry Farming Station, Bellary, South India, was used in this experiment, which was carried out in the greenhouse at Lincoln, Nebraska, during the summer of 1937.

Moist, screened, fertile and well mixed loess soil was uniformly tamped into eight cylindrical, galvanized iron containers that were 9 inches in diameter, 19 inches deep, and contained one-half inch of gravel. The top of each completely filled container was tightly covered with water-proof oilcloth. A tightly fitting 3-inch cork containing 3 half-inch holes was placed in an opening cut in the center of each cover and sealed with liquid glue to prevent loss of moisture. On June 22, two seeds were planted in the soil just below each of the holes in the corks, the holes filled with sand, and the phytometers weighed.

Five days after germination the seedlings were thinned to three per container, *i.e.*, one per opening. The eight phytometers were arranged in two sets of four each and each set was insulated by wrapping it with several thicknesses of heavy brown paper. One lot of six-day-old seedlings was placed 2 feet from a 16-inch electric fan where a wind velocity of 5 m.p.h. was created when the fan was run from 9 to 11 a.m. and from 3 to 5 p.m. the first day. On the next day, the fan was run from 6 a.m. to 6 p.m., and on the third day at 10 a.m. the wind velocity was increased to 11 m.p.h. until 6 p.m. This latter velocity was then maintained from 6 a.m. to 6 p.m. daily throughout the experiment. The phytometers were restored to their original weight at intervals by addition of water. Detailed notes of the

condition of the plants and of water used were taken. The second lot, in the meantime, was placed under conditions that were similar except for the absence of wind. Loss of water was determined by frequent weighing, enough water being added to replace that transpired.

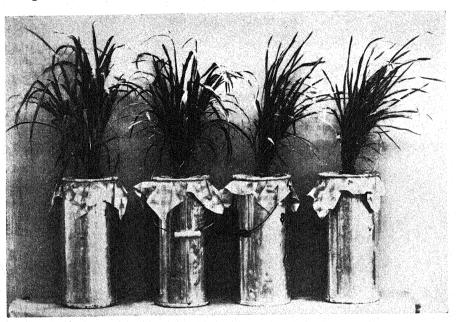


Fig. 1. Two lots of control plants of Setaria italica (left) and two groups that have been exposed to wind 12 hours daily.

Average daily evaporation from Livingston's black spherical atmometers was 46.7 cc. near plants exposed to the wind, and 20.7 cc. near the controls. The summer was very warm and temperatures of 100° to 110°F. were frequently attained during the early afternoon, despite the fact that the greenhouse was unusually well ventilated and the glass partly covered with whitewash. The air temperature (of numerous readings made between 10 a.m. and 2 p.m.—97.1°F.) was 3.3°F. lower about the plants in the wind. The light intensity on the treated plants was 6700 foot candles, which was almost identical with that of the controls. The average relative humidity during the experiment, as determined by numerous readings of a cog psychrometer, was 69 per cent.

At the end of a month of treatment, after weighing the phytometers, the shoots were oven-dried at 90°C. for 24 hours and weighed. The containers were placed in a slanting trough, their sides cut open, and the roots, which had nearly reached the bottoms of the containers, were exposed by carefully washing away all the soil with a gentle stream of water. Root

volumes, obtained by displacement of water, and oven-dry weights were secured.

RESULTS

The effect of the wind became visible on the fifth day when tips and margins of the first three leaves began to dry. Notwithstanding this symptom, the plants continued to grow more vigorously than the controls for the first 13 days of treatment as shown in table 1.

TABLE 1

Effect of wind upon the height of Setaria italica.

AGE OF SEEDLING, DAYS	DAYS AFTER FREATMENT	CONTROL (WITHOUT WIND)	GHT IN CM. EXPERIMENTAL (WITH WIND)
10	4	5.1	6.7
12	6	8.5	12.1
14	8	16.2	21.2
16	10	21.4	24.9
19	13	31.2	32.9
23	17	43.9	38.7
27	21	52.9	47.3
37	31	67.2	59.7

The accelerated growth of the treated plants may have been related to the lower temperature of the surrounding air. After the 13th day, however, the plants in the wind lagged behind the controls. They had shorter, thinner stems and slightly narrower, shorter leaves with dry tips (fig. 1). Adverse effects of the wind treatment used were further shown by the production of fewer tillers and by less dry matter in both tops and roots. There was also a considerable decrease in the volume of the roots. Moreover, water requirement was nearly double that of the controls (table 2).

TABLE 2

Effects of wind upon the development of Setaria italica
(average of 12 plants in each lot)

CRITERIA	CONTROL (WITHOUT WIND)	EXPERIMENTAL (WITH WIND)	RATIO OF CONTROL TO EXPERIMENTAL PLANTS
Height, cm.	67.2	59.7	1:0.89
Number of tillers	5.2	4.0	1:0.77
Thickness of stalk, cm.	0.8	0.6	1:0.75
Width of widest leaf, cm.	1.44	1.27	1:0.88
Weight of shoot, gm.	4.1	2.93	1:0.71
Weight of roots, gm.	1.51	0.89	1:0.59
Volume of roots, cc.	13.75	8.5	1:0.62
Water requirement, lbs.	511.7	968.5	1:1.89
Water transpired, lbs.	6.33	8.16	1:1.29

DISCUSSION

The depressing influence of strong wind upon the growth of vegetation is well known but quantitative data are meager. Blanchard (1934) compared the growth and yield of two orchards of Eureka lemons and found that the factor of improvement in yield due to protection from wind was 5 to 7 and in size of trees about 3. A reduction of about 50 per cent in dry weight of marigolds grown under a constant wind velocity of 15 m.p.h. was reported by Finnell (1928). Martin and Clements (1935) made a thorough study of the effect of constant wind velocities of 5, 10, and 15 m.p.h. on shoots of Helianthus annuus. Using different wind velocities and plants in various stages of development, they found in all experiments that leaf area, stem height and diameter, dry weight, and total transpiration, as well as number of xylem elements and xylem area, decreased with increasing wind velocity. The water requirement at the highest wind velocity, 15 m.p.h., was increased 50 per cent. These authors also give a summary of the conflicting literature on this subject, none of which makes reference to the effect upon root systems.

SUMMARY

Plants of Italian millet (Setaria italica Beauv.) were grown in continuous wind 12 hours daily for 31 days. The tips and margins of the first three leaves began to dry after the fifth day. The treated plants grew more rapidly than the controls the first 13 days, but less rapidly thereafter. Tops of plants subjected to wind were shorter, lighter in weight, thinner stalked, and had narrower leaves and fewer tillers. These plants also had lighter and less bulky root systems. The water requirement was approximately doubled.

The author wishes to express his sincere appreciation to Dr. J. E. Weaver, under whose direction this work was done.

University of Nebraska, Lincoln, Nebraska

Literature cited

- Blanchard, V. F. 1934. Depressing effect of wind on growth and yield of citrus trees. California Citrogr. 19: 206-207.
- Finnell, H. H. 1928. Effect of wind on plant growth. Jour. Amer. Soc. Agron. 20: 1206-1210.
- Martin, E. V., and Clements, F. E. 1935. Studies of the effect of artificial wind on growth and transpiration in *Helianthus annuus*. Plant Physiol. 10: 613-636.

Studies in Penstemon VI. The section Aurator

DAVID D. KECK

Aurator, proposed as a new section in the scrophulariaceous genus Penstemon, contains eighteen species as here defined. These all occur in western North America under semi-arid conditions at moderate elevations. The plants are relatively low, herbaceous perennials, marked by their prominently glandular-viscid inflorescence, explanate anthers and usually by their prominently bearded staminode.

The following herbaria have been consulted in the course of this study:

C-University of California, Berkeley.

CAS—California Academy of Sciences, San Francisco.

CI-Carnegie Institution at Washington, Stanford University, Calif.

CM-Carnegie Museum, Pittsburgh, Pa.

F-Field Museum, Chicago.

GH-Gray Herbarium, Harvard University, Cambridge.

M-Missouri Botanical Garden, St. Louis.

Minn-University of Minnesota, Minneapolis.

NY-New York Botanical Garden.

Ph-Academy of Natural Sciences, Philadelphia.

Po-Pomona College, Claremont, Calif.

Pul—State College of Washington, Pullman.

RM—Rocky Mountain Herbarium, University of Wyoming, Laramie.

SU-Dudley Herbarium, Stanford University, Calif.

US-United States National Herbarium, Washington, D. C.

I am grateful to those in charge of these collections for permission to study materials. I am particularly indebted to Dr. F. W. Pennell, of the Academy of Natural Sciences of Philadelphia, whose authoritative suggestions on problems in *Penstemon* I have sought many times, both in regard to the present section of the genus and many others as well.

BOUNDARIES OF THE SECTION

F. W. Pennell, in his recent monograph on the Scrophulariaceae of Eastern Temperate North America (Acad. Nat. Sci. Phila. Monogr. 1, 1–650, 1935) provisionally treated *Penstemon Cobaea* Nutt., *P. triflorus* Heller, *P. guadalupensis* Heller and *P. albidus* Nutt., as members of a distinct section, *Albidi*. To this proposal I do not agree, because the study of the four, together with the other species included in the present paper, leads me to the conclusion that all must be considered as members of a single section. Thus circumscribed, the group is natural from the standpoints of comparative morphology and distribution, and homogeneous throughout due to a

close interconnection of the components. For example, Pennell would separate the sections Albidi and Cristati on the presence of glands within the corolla-throat in the former and their absence in that position in the latter, but this criterion falters in the cases of P. Jamesii and P. eriantherus, which Pennell would assign to the Cristati, and in P. guadalupensis of his Albidi. Penstemon Jamesii is definitely glandular within the corolla in its two larger subspecies, as much so as the average species of Albidi. Occasionally P. eriantherus is moderately glandular within, especially on the lateral lobes of the lower lip. P. guadalupensis, on the other hand, is sometimes essentially glandless within the corolla. The four species assigned by Pennell to the Albidi are not villous-bearded on the lower lip of the flower, whereas the majority of the other species considered in this paper are. The lack of bearding, however, occurs in some of the latter that are otherwise notably different and widely separated geographically, so the character is one whose presence or absence runs counter to the most probable phylogenetic sequence and consequently its importance should not be magnified.

There is no geographic hiatus between the members of the *Albidi* and the *Cristati*. The various species form a network over the country, occupying adjacent areas after the manner of ecospecies that have evolved from ecotypes, and although the members of the *Albidi* are the easternmost, I find no excuse for grouping them apart, even as a subsection.

Since Pennell's treatment of these four species is adequate and generally available, I have avoided a complete repetition here, contenting myself with summarizing his distributional data and keying out his units. The latter I subscribe to fully, with the exception regarding sections, including his statement that the treatments of *P. triflorus* and *P. guadalu-pensis* are provisional, because my independent examination of material leads me to similar results and does not warrant additional revision. It appears to be a natural presumption that *P. guadalu-pensis* represents a southern derivative of *P. albidus* (or vice versa), whereas *P. Cobaea* and *P. triflorus* are most closely related to each other. Furthermore, it is to all appearances a narrow step from *P. guadalu-pensis*, and perhaps from *P. albidus*, to *P. Jamesii*, *P. auriberbis* and relatives.

Section Aurator, sect. nov.

Low, mostly short-lived herbaceous perennials; stems few to several crowning the taproot or praemorse rootstock, erect; leaves mostly entire but in all species at least potentially toothed, dimorphic, those of the basal rosette petiolate, the lower cauline often petiolate gradually becoming sessile upwards, the upper cauline usually widest at base and often clasping; inflorescence

± prominently glandular-pubescent; calyx-lobes lanceolate; corolla glandular-pubescent without, the throat rounded, scarcely if at all plicate, usually pilose at orifice across base of lower lip; fertile stamens glabrous, their authers sometimes minutely ciliolate-denticulate, sterile stamen usually densely bearded with prominent flattened hairs, rarely glabrate. Type species, *P. eriantherus* Pursh. Included here are the *Albidi* and *Cristati*, variously called species-groups or sections by authors, but in compliance with Article 26 of the International Rules I am proposing a sectional name in substantive form. The Latin noun *aurator*, the gilder, is employed in reference to the prominent yellow beard found on the staminode of most species that simulates a brush dipped in gilt.

KEY TO THE SPECIES OF SECTION AURATOR

KEY TO THE SPECIES OF SECTION AURATOR
 A. Throat glandular within but not villous; staminode lightly bearded; anther-sacs peltately explanate. B. Corolla 25-50 mm. long, 9-25 mm. wide at throat. C. Corolla over 35 mm. long, the throat abruptly much inflated; capsule 12-14 mm. long
D. Corolla pale violet-purple or white; foliage pale green
FF. Leaves scabrid-puberulent; corolla densely glandular-pubescent without and within.
I. Corolla 18–22 mm. long, 7–8 mm. wide at throat
JJ. Throat not glandular within (sometimes sparingly glandular in 16). K. Staminode included; ovary glabrous.
L. Corolla blue-purple; anther-sacs not explanate. M. Inflorescence, including calyces, glandular-pubescent, not additionally puberulent. Utah-Colorado
N. Leaves lanceolate to elliptic, 4–8 mm. wide; staminode bearded on outer half. Utah

LL. Corolla pinkish or reddish. California.
O. Anther-sacs not explanate, 1.3 mm. long; corrolla 14-20 mm. long, somewhat ven-
tricose. East of Owens Valley
OO. Anther-sacs explanate, 0.5 mm. long; corolla 11-14 mm. long, narrowly tubular.
12. P. calcareus
KK. Staminode exserted.
Q. Capsule (and ovary) glabrous.
R. Anther-sacs peltately explanate, the line of contact long; staminode densely
bearded throughout with short orange-yellow hairs.
S. Corolla 13-28 mm. long. Nevada westward
SS. Corolla 30-35 mm. long. Utah
RR. Anther-sacs not fully explanate, the line of contact relatively short; staminode
sparingly bearded with yellow hairs
QQ. Capsule (and ovary) glandular-puberulent.
T. Anther-sacs peltately explanate, as broad as long, the line of contact long.
U. Corolla 20-35 mm. long, 9-14 mm. wide at throat, pilose at orifice
16. P. eriantherus
UU. Corolla 16-25 mm. long, 6-9 mm. wide at throat, more densely pilose at
orifice17. P. Cleburnei
TT. Anther-sacs not explanate, much longer than broad, the line of contact short
Danger Brown Con Ara Mutt

1. Penstemon Cobaea Nutt.

Penstemon Cobaea Nutt., Trans. Amer. Phil. Soc. 2: 5: 182, 1837.

1a. Penstemon Cobaea subsp. Typicus Pennell

Penstemon Cobaea subsp. typicus Pennell, Acad. Nat. Sci. Phila. Monogr. 1: 249. 1935.

P. Hansonii A. Nels., Univ. Wyom. Publ. Bot. 1: 129. 1926.

Open prairies from southeastern Nebraska, southward through Kansas and Oklahoma to the Coastal Plain of southeastern Texas.

1b. Penstemon Cobaea subsp. purpureus Pennell

Penstemon Cobaea var. purpureus Pennell, Proc. Acad. Nat. Sci. Phila. 73: 490. 1921.

P. Cobaea subsp. purpureus Pennell, Acad. Nat. Sci. Phila. Monogr. 1: 250. 1935.

"Rocky calcareous barrens and cliffs, valley of the White River, Ozark Mountains of northern Arkansas and southern Missouri."

2. Penstemon triflorus Heller

Penstemon triflorus Heller, Contr. Herb. Franklin & Marshall Coll. 1: 92. pl. 8. 1895.

A variable species much in need of intensive field study and garden experiment.

2a. Penstemon triflorus subsp. typicus Pennell

Penstemon triflorus subsp. typicus Pennell, Acad. Nat. Sci. Phila. Monogr. 1: 251. 1935.

P. Helleri Small, Bull. Torr. Club 25: 471, 1898. Central Texas from Nolan to Bexar and Uvalde counties.

2b. Penstemon triflorus subsp. integrifolius Pennell Penstemon triflorus subsp. integrifolius Pennell, l. c. P. triflorus var. integrifolius Cory, Rhodora 38: 407. 1936.

Western Texas from the Upper Concho River southerly to Kinney County; apparently overlapping the distribution of subsp. *typicus* in the southern portion of its range and there, due to the consequent hybridization, less clearly differentiated.

3. PENSTEMON GUADALUPENSIS Heller

Penstemon guadalupensis Heller, Contr. Herb. Franklin & Marshall Coll. 1: 92. pl. 7. 1895.

I have seen very scanty material of this species and so am relying wholly upon Pennell's classification.

3a. Penstemon guadalupensis subsp. typicus Pennell Penstemon guadalupensis subsp. typicus Pennell, l.c. 252.

In the upper drainages of the Colorado and Guadalupe rivers of central Texas, from Nolan and Comanche counties to Kerr County.

3b. Penstemon guadalupensis subsp. Ernesti Pennell Penstemon guadalupensis subsp. Ernesti Pennell, l.c. P. guadalupensis var. Ernesti Cory, Rhodora 38: 407. 1936.

Valley of the upper Colorado River in western Texas.

4. Penstemon albidus Nutt.

Penstemon teretiflorus Nutt., Fraser's Catal. 2, n. 66, 1813, nomen nudum. P. albidus Nutt., Gen. Pl. 2: 53. 1818.
P. viscidulus Nees, in Neuwied, Reise Nord-Amer. 2: 444. 1841.

Chelone albida Spreng., Syst. Veg. 2: 813. 1825.

A widespread species of the prairies and plains east of the continental divide from southern Manitoba, Saskatchewan and Alberta, southward to western Minnesota and Oklahoma, northern Texas and easternmost New Mexico.

5. Penstemon Auriberbis Pennell

Penstemon auriberbis Pennell, Contr. U.S. Nat. Herb. 20: 339. 1920.

Stems 10-20 cm. tall, pubescent; leaves linear to linear-lanceolate, 4-8 cm. long, 2-7 mm. wide, entire or nearly so, glabrous or usually puberulent; calyx-lobes linear-lanceolate, usually attenuate; corolla 18-22 mm. long, 7-8 mm. wide at throat, pale lilac to purplish blue with faint guide lines, not

glandular within, the throat ampliate, the limb spreading, the lower lip pilose at base; anther-sacs widely divaricate, dehiscent quite to proximal apices, not explanate; staminode \pm exserted, dilated apically, densely bearded for its entire length with long yellow hairs.

Valleys of the Arkansas and Rio Grande rivers in southern Colorado. Type locality: "a dry sandy sagebrush slope, east of Fountain Creek, northeast of Pueblo, Pueblo County, Colorado, altitude about 1,400 meters."

COLORADO. Kiowa Co.: 10 mi. w. of Haswell, Ownbey 752 (CI). El Paso Co.: Colorado Springs (GH); 15 mi. S. of Colorado Springs, (CI); 18 mi. S. of Colorado Springs, Keck 870 (C, CAS, CI, M, Ph, Po, SU); Fountain (M). Fremont Co.: Canon City, Pennell 6312 (F, GH, M, NY, RM, US), Nelson 10543 (C, M, NY, RM). Pueblo Co.: Pueblo, Pennell 5731 (NY, type; isotypes GH, RM, US), 5733 (F, M, NY, Ph); Swallows, Baker 6 (C, GH, M, NY, RM, US). Otero Co.: Apishipa Creek, Osterhout 2039 (RM); Rocky Ford, Osterhout 2084 (NY). Huerfano Co.: Walsenburg, Bethel et al. 4284 (CAS, CI, M, Ph, RM, SU, US), Nelson 11523 (C, M, NY, RM, SU); La Veta (Ph); Badito, Rydberg & Vreeland 6610 (NY); La Veta Pass, Bethel et al. 4283 (NY, Ph, RM, US). Alamosa Co.: Alamosa, Porter 2029 (CI). Costilla Co.: Sangre de Cristo Creek, Rydberg & Vreeland 5635 (NY). Las Animas Co.: Trinidad, Eastwood 5587 (CAS); Barela (CAS, NY). NEW MEXICO. Union Co.: Emery Gap to Branson, Eggleston 20150 (NY).

6. Penstemon parviflorus Pennell

Penstemon parviflorus Pennell, Contr. U.S. Nat. Herb. 20: 340. 1920.

Stems 15-20 cm. tall, cinereous-puberulent; leaves linear to linear-oblanceolate, 3-5 cm. long, 3-5 mm. wide, finely canescent, entire; calyx-lobes linear-lanceolate, 8 mm. long; corolla 12 mm. long, 5 mm. broad at throat, probably purplish blue, internally not glandular, the throat moderately ampliate, the limb spreading, the lower lip pilose at base; anther-sacs widely divaricate, dehiscent quite to proximal apices, not explanate; staminode scarcely exserted, dilated apically, densely bearded for almost its entire length with long yellow hairs.

Known only from the type collection, made at Mancos, Montezuma County, Colorado, July, 1890, by Alice Eastwood, which I have seen in the U. S. National Herbarium.

This species remains obscure. Additional collections have not been forthcoming despite the fact that much collecting has been done in Montezuma County in the years following Miss Eastwood's original collection and Pennell's description of the species. That it is a rare endemic and not a random introduction of some species from a distant area seems certain,

because its nearest known relative is the Coloradan P. auriberbis Pennell, a species that differs in several features.

Pennell did not note that all the upper leaves of the type specimen are ternate, while the several basal pairs are alternate. If this should prove to be a specific character, it would be a material aid in quickly identifying *P. parviflorus*, for no other species of this subgenus has ternate leaves. But as there is only one specimen preserved at present, we are unable to ascertain whether this will prove to be a constant feature of the species or a unique occurrence. If the latter proves to be the case, or if the species cannot be rediscovered, the possibility must be considered that a seed of *P. auriberbis* was accidentally distributed to Montezuma County of a genetically aberrant constitution, so that it sprouted into a plant that flowered without developing a basal rosette, and that had ternate upper leaves and flowers of less than two-thirds the normal size.

7. Penstemon Jamesii Benth.

Penstemon Jamesii Benth, in DC., Prod. 10: 325. 1846.

Stems 1–4.5 dm. tall, glabrate to pubescent below, always glandular-pubescent above; leaves linear to oblanceolate, 2–10 cm. long, 2–10 mm. wide, entire or sometimes undulately serrate, glabrous or puberulent; calyx-lobes narrowly to broadly lanceolate, acuminate, entirely herbaceous or the margin narrowly scarious; corolla 18–32 mm. long, blue-lavender, the throat broadly ampliate and ventricose; upper lip projecting, glabrous within; lower lip reflexed, usually glandular-pubescent within and prominently bearded with long whitish hairs at orifice, the orifice 9–15 mm. wide, guide lines extending into throat from both lips; anther-sacs widely divaricate, explanate, ca. as broad as long; staminode exserted, bearded almost its entire length with long often septate yellow hairs.

Southern Utah to northern Arizona, southwestern Colorado, New Mexico and the mountains of southwestern Texas.

KEY TO SUBSPECIES

7a. Penstemon Jamesii subsp. typicus, nom. nov.

Penstemon Jamesii Benth., l.c.

P. similis A. Nels., Bull. Torrey Club 25: 548, 1898. Nelson redescribed this New Mexican species under this name, believing that P. Jamesii was the plant of the Red Desert of southwestern Wyoming, which, instead is P. Cleburnei Jones. The first number he cites is Fendler 575, which was probably collected near Santa Fe.

Eastern New Mexico to southwestern Texas. Type locality: "in montibus Scopulosis (James in itinere Longii!)" The route followed by James' part from the Arkansas River in Colorado near the vicinity of what is now La Junta, was straight south into New Mexico veering easterly to strike the Canadian River in western Texas. Apparently the only portion of New Mexico traversed by the party lies now in Union County and we suspect the type came from there.

NEW MEXICO. Exact station unknown, Long's Expedition, Dr. James (NY, type). Colfax Co.: Vermejo River, Goodding 18 (CI); Raton. St. John 72 (GH), McKelvey 4861 (CI): Ute Park, Standley 13745 (US); E. of Cimarron, Wilkens 2456 (Ph). Mora Co.: between Wagon Mound and Las Vegas, McKelvey 4909 (CI); Mora, Arsene & Benedict 17168 (Ph). SAN MIGUEL Co.: Pajarila (M); Las Vegas, Arsene 19413 (Po), Goodding 17 (CI); San Miguel, Fendler 579 (GH); Arroyo Pecos, Standley 5168 (US); Las Vegas to Santa Fe, Osterhout 7032 (Ph); Rowe, Pringle (F). SANTA FE Co.: Santa Fe, Fendler 575 (CI, F, GH, M, NY, Ph, US), Heller 3605 (GH, M, NY, Po, Pul, SU); Glorieta, Vasey (GH, US). SAN-DOVAL Co.: Placitas (RM); Forest Park, Sandia Mts., Castetter 1265 (RM); Las Palomas, Sandia Mts., Ellis 480 (NY). Quay Co.: Tucumcari, Abbott (CM). LINCOLN Co.: Lincoln, Earle 653 (NY); W. of Hondo, Wilkins 2122 (Ph). OTERO Co.: Highrolls (CI, Ph); Nogal Canyon, Sacramento Mts. (CI). Eddy Co.: Carlsbad Caverns, Nelson 11408 (C, RM); Queen, Standley 40687 (US); Guadalupe Mts., near Three Forks of Rocky Arroyo, Wilkins 1855 (Ph); Last Chance Canyon, Wilkens 1913 (Ph). TEXAS. PARMER Co.: Farwell, McKelvey 2770 (Ph). Culberson Co.: Pine Canyon, Guadalupe Mts., Chase 5994 (US); Van Horn's Wells, Thurber 570 (NY). JEFF DAVIS Co.: Fort Davis, Jones 25601 (Po). Brewster Co.: Alpine, Palmer 30564 (Ph); 5 mi. W. of Alpine, McKelvey 1986 (Ph).

7b. Penstemon Jamesii subsp. ophianthus (Pennell), comb. nov.

Penstemon ophianthus Pennell, Contr. U.S. Nat. Herb. 20: 343. 1920.

P. pilosigulatus A. Nels., Univ. Wyom. Pub. Bot. 1: 130. 1926. "This also was secured near Flagstaff, Arizona and is reported by Mr. Hanson from 'the Canadian zone and above.' His no. 554, June 6, 1923, is the type." The type is characteristic of much material from northern Arizona which develops a compact rosette of rather short, narrow leaves from which the flowering stem, with its well spaced and linear leaves, emerges. However, gradations are numerous to forms with more ample foliage such as the type of P. Jamesii ophianthus has, and these obscure a true regional difference among the races of this subspecies.

Western Colorado and southern Utah southward to western New Mexico and northern Arizona. Type locality: "Thurber, Utah."

COLORADO. Montrose Co.: Naturita, Payson 347 (CM, F, GH, M, Pul, RM). UTAH. WAYNE Co.: Thurber, Jones 5708 (US, type; isotypes M, NY, Po); Bicknell, Cottam 4509 (Ph). GARFIELD Co.: Siler (M); Pleasant Creek Camp, Dixon 286 (RM). WASHINGTON Co.: Chadwick's above St. George, April 1913, Johnson (Po, a poor, atypical specimen, possibly distinct). NEW MEXICO. ? Co.: between Gallup and Albuquerque, McKelvey 2336 (GH, Ph, Po). McKinley Co.: W. of Gallup, McKelvey 4593 (CI); Fort Defiance, Palmer 108 (NY). VALENCIA Co.: San Mateo, Mount Taylor, Castetter 1794 (RM). SANDOVAL Co.: Sandia Mts., Ellis 374 (NY, US). Socorro Co.: Santa Magdalena Mts., Vasey (GH, US); Magdalena, Herrick 652 (US). CATRON Co.: W. of Patterson, Wooton (US). ARIZONA. MOHAVE Co.: Sturgenegger Ranch, Cottam et al. 4164 (Ph). Coconino Co.: Red Butte, Ward (US); El Tovar, Grand Canyon, Eastwood 5661 (CAS); 10 mi. S. of Grand Canyon, Ward (NY); Grand Canyon-Flagstaff, Ferris & Duncan 2281 (CAS, M, NY, SU); Williams, Jones (Po); San Francisco Peak, Purpus 7074 (C, M, Po, US); Flagstaff, Hanson 554 (RM, type of P. pilosigulatus; isotype M), Mac-Dougal 130 (C, GH, NY, Ph, RM, US); 8 mi. E. of Flagstaff (CI, Ph); 15 mi. E. of Flagstaff (M, NY, Ph). YAVAPAI Co.: Ash Fork, Jones 94 (C, GH). NAVAJO Co.: Cedar Springs, Toumey 368 (SU, US); Taylor (US); Pinedale, Zuck (US). GREENLEE Co. (?): San Francisco Mts., July 1, 1892, Wooton (NY, US).

7c. Penstemon Jamesii subsp. breviculus, subsp. nov.

Corollis 14–16 mm. longis 5–6.5 mm. latis fere tubulosis haud glandulosis intus, ceteroqui subsp. typicus similibus.

Type: Baker, Earle & Tracy 410, collected on dry plains below Mancos, Montezuma County, Colorado, July 8, 1898, Pomona College Herbarium, number 7232. Isotypes CI, F, GH, M, NY, Ph, US.

COLORADO. Montezuma Co.: E. of Cortez, McKelvey 4640 (CI). NEW MEXICO. SAN JUAN Co.: Aztec, Baker 601 (GH, M, NY, Po,

RM, US); Chuska, Marsh 102 (US).

Possibly careful field study would demonstrate that this unit is fully deserving of specific rank. On the present data, however, it appears to compose a natural subspecies, the small, scarcely inflated corollas, without glands within the limb or throat, being a constant characteristic of the collections cited and differing appreciably from all others in the species. Pennell cited the type collection under his P. ophianthus, but the two do not overlap in corolla-size. It is true that the type collection of P. ophianthus, and Payson 347, from Naturita, Colorado, both from the periphery of the subspecies and not typical of the unit, have very few glands within

the lower lip; but normally P. Jamesii subsp. ophianthus is obviously glandular on the lower lip.

It became necessary to reduce *P. ophianthus* to subspecific rank after studying many collections from New Mexico, because subsp. typicus contains much variation even within so restricted a region as Santa Fe County. The variable characters include first of all flower-size and the amount of inflation in the throat, then leaf-shape, serration or non-serration of the margin, sepal-length, height of plant, compactness of the inflorescence, etc. There is about as much variation within neighboring races of subsp. typicus as between some of them and subsp. ophianthus. The range of typicus merges with that of ophianthus and no evident break in the morphology of the forms across an east to west transect has been discovered. Nevertheless, two excellent subspecies exist that roughly divide the bulk of the species into eastern and western halves, while subsp. breviculus forms a marginal island in the general distribution whose members may owe their unique character to an early contact with some other species of the section.

8. Penstemon Moffatii Eastw.

Penstemon Moffatii Eastw., Zoe 4: 9. 1893.

Stems 1-3 dm. tall, puberulent; leaves entire or essentially so, puberulent, basal with linear-oblanceolate to elliptic blades, cauline linear-oblong; calyx-lobes acuminate, glandular-pubescent; corolla 12-22.mm.long, blue-purple (?), neither glandular nor pubescent within or sometimes sparingly pilose at base of lower lip; anther-sacs widely divaricate, dehiscent throughout but not explanate; staminode mostly included, moderately dilated apically, with a moderate yellow beard along its outer half.

KEY TO SUBSPECIES

8a. Penstemon Moffatii subsp. typicus, nom. nov.

Penstemon Moffatii Eastw., l.c.

Central Utah to western Colorado. Type locality: Grand Junction, Colorado.

UTAH. UTAH CO.: Thistle, Jones (GH, NY, SU). DUCHESNE CO.: Duchesne (Theodore), Jones (Po). Grand Co.: Thompson's Springs (Thompsons), Jones (C, CAS, F, GH, M, NY, Po, RM, SU, US). COLO-

RADO. MESA Co.: Mack, Jones (Po); Grand Junction, May 1892, Eastwood (CAS, type; isotypes C, GH, M, US), May 1891, Eastwood (M, NY, SU), Pennell 6173 (F, GH, NY, RM, US), Gunnison Mesa, Grand Junction, Eastwood 5100 (CAS, SU); 7 mi. S.E. of Grand Junction, Keck 802 (CI); De Beque, Osterhout 4249 (Ph), 4482 (NY).

8b. Penstemon Moffatii subsp. Paysonii (Pennell), comb. nov.

Penstemon Paysonii Pennell, Contr. U.S. Nat. Herb. 20: 342. 1920.

Montrose County, Colorado. Type locality: Naturita.

COLORADO. Montrose Co.: Naturita, Payson 257 (M, type; isotypes F, GH, CM, Minn, RM), 990 (RM), 3864 (C, GH, M, Ph, RM).

8c. Penstemon Moffatii subsp. Marcusii, nom. nov.

Penstemon pseudohumilis Jones, Contr. West. Bot. 12: 65. 1908; not Rydb., Mem. N. Y. Bot. Gard. 1: 347. 1900.

Carbon County, Utah. Type locality: Price.

UTAH. CARBON Co.: Price, June 29, 1898, Marcus E. Jones (Po,

type), June 20, 1898, Stokes (C).

This species has a rather discontinuous distribution over one of the less well known regions botanically. Consequently it is not easy to properly evaluate the importance of the considerable variation in flower-length that may be as great as 4 to 5 mm. from single localities such as Thompsons, Grand Junction and Naturita. Considering the high aridity of the region during much of the year, such variations may principally be due to modification alone. At all events, the local variability greatly decreases the importance of this character which was the chief one advanced in support of Paysonii as a species. Also, subspp. Paysonii and Marcusii are very similar in foliage characters although they are far apart geographically and a portion of the range of subsp. typicus intervenes between them. Such recombinations of characters speak for the phylogenetic unity of the species.

9. Penstemon dolius Jones ex Pennell

Penstemon dolius M. E. Jones ex Pennell, Contr. U. S. Nat. Herb. 20: 341. 1920.

Stems 5-15 cm. tall, cinereous-puberulent; leaves entire, densely cinereous-puberulent throughout, basal with lanceolate to elliptic blades, upper cauline linear-lanceolate, narrowed to a petiole-like base; inflorescence scarcely viscid; calyx-lobes linear-lanceolate, acuminate, densely puberulent with a few gland-tipped hairs interspersed; corolla 15-20 mm. long, 4-6 mm. broad at throat, blue-purple, glabrous within or sometimes sparingly pilose at base of lower lip; anther-sacs widely divaricate, dehiscent throughout but not explanate; staminode included, moderately dilated apically, with a sparse to moderate yellow beard along its outer half; capsule glabrous.

Upper Sonoran Zone, from 5,000 to 7,300 ft. elevation, in heavy soils from Elko County, Nevada, to Duchesne and Sevier counties, Utah. Type locality: "Willow Springs, Nevada." Personal communication from Jones locates this as Willow Springs Pass, Deep Creek Mts. (E. flank of the Ibapah Mts.), west of Troutcreek, Juab County, Utah, not far east of the Nevada state line.

NEVADA. ELKO CO.: Ferguson Spring, June 14, 1900, Jones (Po); Cobre, June 26, 1907, Jones (Po). White Pine Co.: Aurum, May 30, 1893, Jones (Po). UTAH. Tooele Co.: Deep Creek (=Ibapah, acc. M.E.J.), June 6, 1891, Jones (Po), June 3, 1917, Jones (Po); Clifton, June 19, 1891, Jones (Po). Juab Co.: Willow Spring Pass, June 5, 1891, Jones (US, type; isotypes C, CAS, CI, GH, M, NY, Po). Sevier Co.: 3 mi. N. of Redmond, Eggleston 11130 (US); Vermilion, June 4, 1901, Jones (Po). Duchesne Co.: Duchesne (Theodore), May 12, 1908, Jones (Po), May 14, 1908, Jones (Po); Duchesne (Theodore) to Myton, May 19, 1908, Jones (CI, M, NY, Po, SU, US).

10. Penstemon pumilus Nuttall

Penstemon pumilus Nutt., Jour. Acad. Phila. 7: 46. 1834.

Stems several from the branching root-crown surmounting a praemorse rootstock, 5–12 cm. tall, cinereous-pubescent throughout; leaves linear to linear-oblanceolate or narrowly spatulate, 15–25 mm. long, 2–5 mm. wide, obtuse or acute, entire, all narrowed to base; inflorescence scarcely viscid, abbreviated; calyx 6–7 mm. high, the lobes acuminate, puberulent with fine gland-tipped hairs interspersed; corolla 14–20 mm. long, 4–6 mm. broad at throat, blue-violet, sparingly glandular-puberulent without, glabrous within; anther-sacs divaricate, dehiscent throughout but not explanate; staminode included, with moderate beard of short yellow hairs almost throughout its length.

Infrequent in the valleys of the upper Salmon and Little Lost rivers, Idaho, at 1500–1900 m. elevation. Type: "On the borders of Little Goddin river, near the sources of the Columbia river. Flowering in June." Wyeth knew the Little Lost River as the Little Goddin River.

IDAHO. CUSTER Co.: 7 mi. up Morgan Creek, Pennell 15274 (CI, Ph); Challis, Macbride & Payson 3211 (GH, M, RM). BUTTE Co.: Little Goddin River (Little Lost River), Wyeth (British Museum, type, the label bearing the additional information "dry soil nr. a brook"; phototypes C, CI, GH, SU; isotypes GH, NY, Ph); 3 mi. N. of Howe, Pennell 15190 (CI, Ph); 5 mi. NW. of Howe, Pennell 15195 (CI, Ph).

The type collection is the only one I have seen in good flower. However,

old flowers on the two collections from Custer County appear to have been no longer than 10-14 mm., whereas those on the type range in length from 16-20 mm. Inadequate material at present prevents me from stating whether this species is variable in flower-size merely at random or in definite geographic directions.

Penstemon pumilus grows in the same region with P. Whitedii subsp. tristis, but is readily distinguishable by its glabrous capsule, sparingly bearded staminode, small less divergent anther-cells, canescent herbage,

and by its finer, shorter, gland-tipped hairs on the calyx.

The closely allied P. dolius of Utah and eastern Nevada is separable from P. pumilus by its broader leaves and its longer and narrower sepals, but the two apparently are of common origin.

11. Penstemon monoensis Heller

Penstemon monoensis Heller, Muhlenbergia 2: 246. 1906.

P. divergens Jones, Contr. West. Bot. 12:64, 1908. Type locality: "Bishop, Owen's Valley, California, 5000 feet altitude, May 15, 1897 [M. E. Jones]."

Stems 15-35 cm. tall, densely cinereous-puberulent; leaves entire, the margin often crisped, densely scurfy puberulent, large, the basal with lanceoblong to broadly oval blades, the cauline narrowly elliptic below to deltoidovate and broadly clasping above; calyx-lobes acuminate, viscid-pubescent; corolla 14-18 or 20 mm. long, 4-6 mm. broad at throat, "rose-purple" or "winered," not marked with guide lines, glabrous and glandless within or sometimes sparingly pilose at base of lower lip; anther-sacs divergent, dehiscent quite to proximal apices, not explanate; staminode not reaching to orifice, not dilated, strongly bearded for its outer half with fine rather short yellow hairs; capsule glabrous.

Occasional on the desert ranges bordering Owens Valley, California, at elevations of 1400-1600 meters. Type locality: "The type is no. 8331 [Heller], collected May 25, 1906, in the extreme southern part of Mono County, California, along the base of the White Mountains near the Southern Belle Mine."

CALIFORNIA. Mono Co.: Coldwater Canyon, White Mts., May 1913, K. Brandegee (C); near Southern Belle Mine (Inyo Co.), Heller 8331 (C, F, GH, M, NY, Ph, SU, US, isotypes). Invo Co.: Bishop, May 15, 1897, Jones (Po, type of P. divergens; isotypes C, M, US); Lee Mine, Hunter Ranch Mts., Austin 526 (C, NY); 15 mi. N. of Darwin, Hall & Chandler 7176 (C, GH, Po, SU); 2 mi. W. of Darwin, Munz 12490 (C, F, M, Po, SU); Darwin, Hall & Chandler 7104 (C, M).

12. Penstemon calcareus Brandegee

Penstemon calcareus Brandegee, Zoe 5: 152. 1903; not Jones, 1908.

P. desertorum Jones, Contr. West. Bot. 12: 59. 1908. Type locality: "This grows in clefts of the rocks, at 4000 feet altitude, in the Tropical Life Zone at Kelso, California, May 2, 1906 [Jones]." This is on the west slope of the Providence Mountains. Cf. Munz & Johnston, Bull. Torrey Club 49: 42. 1922.

Stems 5–25 cm tall, densely pruinose-puberulent, anthocyanous; leaves entire or some of them remotely and obscurely denticulate, densely puberulent on both surfaces to glabrate on the lower side, basal with elliptic to broadly ovate blades 15–40 mm long, cauline linear- to oblong-lanceolate, those subtending the inflorescence often subcordate-amplexicaul; calyx-lobes anthocyanous, narrowly lanceolate, viscid-pilose, accrescent; corolla 12–17 mm long, 2.5–4 mm broad at throat, light rose-red to rose-purple, not marked with guide lines nor glandular within, sparingly pilose at base of lower lip, the limb equally 5-lobed; stamens short; anther-sacs widely divaricate, very small, almost as broad as long, explanate; staminode included, not dilated, strongly bearded for $\frac{2}{3}$ its length with rather coarse golden-yellow hairs; capsule glabrous.

Localized in the Grapevine Mountains, at the north end of Death Valley, and in the Providence Mountains, Mohave Desert, California, at elevations of 1200–1800 meters. Type locality: "... the face of perpendicular limestone cliffs of Providence Mt."

CALIFORNIA. Inyo Co.: Titus Canyon, Grapevine Mts., May 31, 1935, Gilman (Po); Leadfield, Grapevine Mts., 5000 ft., Gilman 2361 (Po), ditto, 6000 ft., Gilman 2384 (CI, Po), ditto, 1109 (US). San Bernardino CO.: Providence Mts., May 27, 1902, T. S. Brandegee (C, type; isotype C); Bonanza King Mine, Munz, Johnston & Harwood 4154 (Po, RM, SU, US); Kelso, May 2, 1906, Jones (Po, type of P. desertorum; isotypes C, Ph).

The desert mountain ranges in which this species has been found are about 160 miles apart and it might be wondered that a species of so limited a distribution, so ruthless an environment and so little opportunity for migration had not produced a recognizably distinct race at each center of its distribution. As a matter of fact, the first collection that came to my notice from the Grapevine Mts., namely the Titus Canyon specimen, differed from the Providence material in having greener leaves, narrower corollas, longer stamens, anther-cells of different shape and a hooked staminode with shorter beard. Subsequent collections from the Grapevines, however, have minimized or reversed these differences with the exception that in all, the leaves have less puberulence and the staminode has a shorter beard. It is well known that the desert environment may effect wide modifications in the same plant from one season to the next. In this species, as yet relatively poorly collected and in which considerable variability has been noted to occur in the floral structures at one locality, there can be but

little justification at present for stressing the minor morphological differences that happen to coincide with the geographical.

The discovery of *P. calcareus* in the Grapevine Mts. brings its known range much closer to that of *P. monoensis*, the other reddish flowered Calirornian member of this section. The two species share many features in common and are surely very closely related, but a number of qualitative differences separate them. *Penstemon monoensis* has a larger and somewhat ventricose corolla, minutely denticulate-ciliate anther-cells that are not explanate and of more than twice the length, and a more densely and softly bearded staminode.

13. Penstemon miser A. Gray

Penstemon miser A. Gray, Syn. Fl. 2(1): 441. 1886.

Stems 10-25 cm tall, cinereous-puberulent; leaves mostly entire, some remotely serrulate or sinuately toothed, densely cinereous-puberulent throughout, basal with linear-lanceolate to elliptic blades, upper cauline linear to oblong; calyx-lobes acuminate, strongly glandular-pubescent, not puberulent, variable in size; corolla markedly variable, 13-28 mm long, 4.5-10 mm wide (!), dull lavender, purple guide lines within throat, not glandular within, strongly pilose with yellow-white hairs at base of lower lip; anther-sacs widely divaricate, very small, as broad as long, explanate or nearly so; staminode exserted, not dilated, strongly bearded for its entire length with stiffish deep orange hairs; capsule glabrous.

Malheur County, Oregon, southward to central Nevada and northeastern California, at elevations of 900 to 2200 meters. Type locality: "Eastern Oregon, along the Malheur River, Cusick."

OREGON. Malheur Co.: sterile soils of the Malheur (River), Cusick 1239 (GH, type; isotypes Ph, US); Malheur Valley near Harper Ranch, Leiberg 2226 (C, GH, NY, US). Harney Co.: East base of Stein's Mt., May 30, Train (Oberlin). CALIFORNIA. Modoc Co.: 9 mi. W. of Alturas, near Pitt River, Applegate 869 (SU, US). Lassen Co.: top of Diamond Mt., Susanville, Perkin's Ranch, June 28, 1897, Jones (Po). NEVADA. Elko Co.: E. of Wells, Eastwood & Howell 317 (CAS, CI); 8 mi. S. of Wells, Keck 921 (CI, SU); Sprucemont, July 21, 1891, Jones (Po); Overland Pass, Ruby Mts., Mason 4823 (CI). White Pine Co.: 7 mi. S.W. of Ely, Keck 616 (CI, SU). Nye Co.: 4.8 mi. E. of Currant at White Pine County line, Keck 605 (C, CAS, CI, GH, M, NY, Ph, Po, Pul, SU, US); S. Twin River, June 8, 1933, Goddard (C, CI). Eureka Co.: Eureka, Kennedy 845 (RM); Robert's Station, Monitor Valley, Watson 778 (GH, NY, US).

The variability in flower-size in P. miser is perplexing. Material from

Malheur Co., Oregon, is relatively small-flowered (15 mm. long, 5-6 mm. wide), with a gradually ampliate but narrow throat; that from Harney Co. is appreciably larger in this respect, while in that from Modoc Co.. California, it is half again as long and 9 mm. wide, the ampliate throat flaring abruptly from the narrow tube. In eastern Nevada the situation is repeated with even more variation. In Elko Co. the collections tend to be rather uniformly larger than the type and more ampliate, but less abruptly ventricose than the Applegate collection from Modoc County. Keck 605 and 616 are similar with corollas 13-14 mm. long and only 4.5 mm. wide. In startling contrast is the collection from relatively nearby in Nye County, Goddard, in which the flowers are 28 mm. or more long and 10 mm. wide! It is determined from an ample number of collections that differences in flower-size run counter to geographic divisions, so we cannot do otherwise on the basis of present evidence than admit these striking variations within the same taxonomic unit. The only other character that is noticeably variable is the shape of basal leaves, which may be nearly linear or almost oval in the same local colony. In other respects this species is quite uniform and there is no indication that it is unnatural.

14. PENSTEMON GRAHAMII Keck

Penstemon Grahamii Keck ap. Graham, Annals Carnegie Mus. 26:331. 1937. Stemsfew (1-3), erect, from a praemorse fibrous-rooted rootstock, 12-18 cm tall, retrorse-pubescent quite to the base; leaves entire, rarely obscurely toothed, glabrous below the inflorescence or essentially so, coriaceous, prominently reticulate veined, slightly glaucous, dimorphic; basal with lance-ovate to oval blade, the largest of which are 20-35 mm long, 15-20 mm wide, obtuse, with winged petioles half as long; cauline oblong, clasping or subcordate at base, obtuse or acute, very gradually reduced within the inflorescence, the lower pairs ± equaling the flowers; inflorescence glandular-pubescent, composed of 2-6 verticillasters; peduncles nearly erect, stout, 3-5-flowered; calyx 7-9 mm high, accrescent, moderately pubescent with prominent gland-tipped hairs, the lobes lanceolate, merely acute, ± coriaceous, the margin at base narrowly hyaline; corolla 30-35 mm long, 11-12 mm broad at throat, light to deep lavender, lower lip striped with red-purple, glandular-pubescent without, glabrous within except for a sparse beard of white villous hairs across the base of lobes of lower lip; tube narrow, abruptly expanding into a strongly arched throat not as long; limb equaling or exceeding throat, widely gaping, the erect upper lip 10-12 mm long, its lobes $\frac{1}{3}$ the length, exceeding the sharply recurved lobes of the lower lip; anthers exceeding orifice, the sacs widely divaricate, explanate, almost as broad as long; staminode exserted, prominently and densely bearded on all sides for its entire length with deep orange flattened hairs 0.5 mm long, not dilated but falcate apically; ovary and capsule glabrous.

Type: Edward H. Graham, no. 7883, Carnegie Museum Herbarium, collected on a talus slope, west side of Green River, south of mouth of Sand Wash, Uintah County, Utah, at 1370 meters altitude, May 27, 1933.

Known from one other collection taken on a bench west of Green River, north of the mouth of Sand Wash, Uintah County, Utah, at the same

elevation and date as the type, Graham 7916 (CM, CI, Ph).

This plant is undoubtedly a very narrow endemic of the Uinta Basin. Not far to the west occurs P. dolius, a species with which the present novelty has very little in common; and to the southward is found P. Moffatii, likewise but distantly related. It has some habital features in common with P. Cleburnei, and a flower-size resemblance with P. eriantherus, both of which occur well to the northward of it in Wyoming. However, the most distinctive features of P. Grahamii, its corolla with peculiar shape and ratio between length of tube and throat, and its staminode, are duplicated only in P. miser, which occurs from Nevada westward. The remarkable flower of P. Grahamii is found on a smaller scale in the large-flowered forms of P. miser, but not elsewhere in this section. Likewise, the falcate staminode, so densely bearded throughout its length with bright orange short hairs, is quite alike in the two species except that in P. Grahamii the beard is quite as dense on the lower as on the upper side. Accordingly, in floral characters there is considerable similarity between P. Grahamii and P. miser, and in vegetative characters, between it and P. Cleburnei.

15. Penstemon Gormanii Greene

Penstemon Gormanii Greene, Ottawa Naturalist 16: 39. 1902.

Stems 1–3 dm tall, glabrous below, glandular-pubescent above; leaves entire or sometimes shallowly serrulate apically, basal with narrowly oblanceolate to spatulate blades, acute or obtuse, glabrous, upper cauline lanceolate, those within the inflorescence glandular-pubescent; calyx-lobes acuminate, pilose with gland-tipped hairs; corolla 18-25 mm long, 8-10 mm broad at throat, blue-purple, not glandular within, rather strongly pilose at base of lower lip; anther-sacs widely divaricate, dehiscent throughout but not explanate, longer than broad; staminode slightly exserted, moderately bearded for more than half its length with long yellow hairs; capsule (and ovary) glabrous.

Gravelly or rocky slopes and hillsides in the drainage of the upper Yukon River and Yukon Valley, Yukon Territory and adjacent Alaska. Type locality: "Dry gravelly slopes of hills in Yukon Valley, June 9, 1899. M. W. Gorman."

ALASKA. Chandalar River, approx. 67° N.×147° W., June 1927,



Mertie (F). YUKON TERRITORY. Dry Gulch, Yukon Valley, Gorman 1011 (US, type; isotype NY); Fifty Mile River, June 28, 1899, Bolton (Ph, US); Dawson, Anderson 1898 (NY), 1916, Kusche (GH), Beauchamp Expedition 82 (C), Eastwood 284 (CAS, GH, Po); banks of Klondyke, Aug. 1898–1901, MacLean (C, GH, Po); Five Finger Rapids, Aug. 21, 1899, Williams (NY), Tarleton 50b (NY); Lake Laberge, Tarleton 50a (NY); White Horse Rapids, July 13, 1930, Setchell & Parks (C, CAS); Carcross, Eastwood 690 (GH); Bear Creek, Lake Dezadeash, Aug. 6, 1920, Müller (Ph); Lake Noris (?), hear head of Yukon River, Schwalka 66 (GH).

16. PENSTEMON ERIANTHERUS Pursh

Penstemon eriantherus Pursh, Fl. Am. Sept. 2: 737. 1814.

P. cristatus Nutt., Gen. Pl. 2: 52. 1818. Type locality: Missouri River, in the present state of South Dakota.

Chelone erianthera Steud., Nom. Bot. 186. 1820-4.

C. cristata Spreng., Syst. Veg. 2: 813. 1825.

Penstemon saliens Rydb., Mem. N. Y. Bot. Gard. 1: 344. 1900. Type locality: Columbia Falls, Montana.

P. eriantherus subsp. saliens Pennell, Contr. U.S. Nat. Herb. 20: 343. 1920. Stems 1-3 dm tall, villous to canescent; leaves entire to saliently and remotely toothed, glandular-pubescent to canescent, basal with lanceolate to ovate blades, upper cauline lanceolate to oblong; calyx-lobes acuminate, strongly viscid-pubescent; corolla 20-35 mm long, 9-14 mm broad at throat, "light blue-magenta" or "purplish violet," guide lines of deeper color within throat, not glandular within, or somewhat glandular-pubescent on particularly the lateral lobes of lower lip, strongly pilose at base of lower lip; anthersacs widely divaricate, explanate or nearly so, as long as wide or somewhat longer than wide, with broad line of contact; staminode prominently exserted, strongly bearded throughout its length with long yellow septate hairs; capsule (and ovary) glandular-puberulent.

Western North Dakota, South Dakota and Nebraska, westward throughout Montana and all but southwestern Wyoming to Spokane Co., Washington, avoiding Idaho by way of southern Alberta and British Columbia. Type locality: "In upper Louisiana, Bradbury . . . " According to Pennell, this was taken along the Missouri River in the present state of South Dakota.

This species has been mapped and citations made of its distribution by Pennell, so I am confining citations here to a list of counties from which I have seen material, with full citation in the northwestern portion of the range that Pennell did not treat.

¹ Pennell, F. W.: Monograph I. Acad. Nat. Sci. Phila. 256. 1935, as P. cristatus.

NORTH DAKOTA: Mercer, Morton, Grant, Stark, Billings, Slope. SOUTH DAKOTA: Campbell, Hughes, Stanley, Mellette, Corson, Meade, Butte, Pennington, Custer. NEBRASKA: Thomas, Dawes, Morrill, Sioux. COLORADO: Weld. WYOMING: Weston, Niobrara, Goshen, Laramie, Converse, Albany, Carbon, Sheridan, Big Horn, Park, Yellowstone Nat'l Park. MONTANA: Dawson, Judith Basin, Carbon, Stillwater, Sweet Grass, Cascade, Meagher, Park, Gallatin, Lewis and Clark, Jefferson, Madison; GLACIER Co.: Midvale, Umbach 140 (F, NY, SU, US). Powell Co.: Deer Lodge Valley, 1906, Jones (Po). Deerlodge Co.: Anaconda, 1905, Jones (Po). BEAVERHEAD Co.: Lima, 1908, Jones (Po); Monida, 1908, Jones (Po). Flathead Co.: Columbia Falls, Kennedy 53 (NY, type of P. saliens), Williams 126 (US); Kalispell, Wilcox 369 (NY). MISSOULA Co.: Missoula, Kirkwood 1390 (C, CAS, CI, F, Ph). LINCOLN Co.: Tobacco Mts., Butler 5043 (NY). ALBERTA: Macleod, 1913, Moodie (US); Crows Nest District, Castle River Forest Station, Brinkman 3087 (NY). BRITISH COLUMBIA: Fort Steele, Anderson 6245 (NY, Pul); Fairmont Hot Springs, Sanson 1009 (NY); Cranbrook, 1915, Garrett (NY). WASHINGTON: SPOKANE Co.: Spokane Falls, Leiberg 28 (GH); Spokane, Kilburge 873 (CI); between Spokane and Marshall, Suksdorf 9009b (Ph); Waikiki, 1913, Turesson (RM).

A species of so wide a distribution not unnaturally displays considerable variation. This affects many of the prominent characters including size of the plant as a whole and of its various parts individually, pubescence, leaf-shape, flower-color, bearding within the corolla, degree of explanation in the anther-cells and their shape, etc. Were two or more of these variables to become fixed over a portion of the range of *P. eriantherus*, thereby establishing a recognizable geographic unit, it would be desirable to name such a unit.

As this goes to press I learn that careful field studies during the past summer by Dr. F. W. Pennell have disclosed the occurrence of two races in western Montana that differ appreciably from each other and that stand out from other forms in this variable species because each occurs over a considerable area to the exclusion of other races.

In the vicinity of Bozeman, many collections were made of a race in which the flowers attain maximum size for the species. Apparently most, if not all, of the material from Gallatin County is assignable to this unit. It may be designated var. **grandis** Pennell et Keck, var. nov., foliis caulinis usque ad 70 mm. longis, 12 mm. latis; corolla 30–42 mm. longa latissime campanulato-ampliata. Type: F. W. Pennell & F. B. Cotner 20511 (Ph), from black soil over limestone, 5800–6000 ft. alt., divide between Rocky and Bridger Mts., east of Bozeman.



In Beaverhead County, a low, small-flowered form with narrowly linear cauline leaves occurs exclusively. This is var. redactus Pennell et Keck, var. nov., foliis caulinis usque ad 65 mm. longis 6 mm. latis; corolla 18–24 mm. longa, ore hiante. Type: F. W. Pennell 20605 (Ph), from gravelly and stony slopes, 7100–7200 ft. alt., south-east of Sawyer, along Bear Creek, Beaverhead Mts., 16 miles east of Monida, June 28, 1937. Pennell also collected this at Lima and the material cited above from Beaverhead County is also assignable to this variety.

The type of *P. saliens* Rydb. is a specimen with unusual leaf-shape and toothing not shared by other collections from that region. To attempt to expand that concept to include all materials from western Montana northwestward leads into serious difficulties, for one must depend upon leaf characters in some cases, on flower-size in others and purely on geographic location elsewhere as, for instance, in Missoula Co., Montana. Thus, I believe that for practical considerations this species must be treated rather broadly. Sufficient detail must still be observed to satisfactorily separate *P. Whitedii* and its subspecies from *P. eriantherus*, but there the line seems to mark closely related ecospecies.

17. Penstemon Cleburnei Jones

Penstemon Cleburnei M. E. Jones, Contr. West. Bot. 12: 62. 1908.

P. auricomus A. Nels. ex Rydb., Bull. Torrey Club **36**: 688. 1909. "Pentstemon Jamesii A. Nelson, Bull. Torrey Club **25**: 547. 1898" (as to description). Type locality: Red Desert of Wyoming.

Stems 1–2 dm tall, pubescent; leaves entire, rarely obsoletely toothed, strigillose, basal with oblanceolate to broadly ovate (up to 4 cm broad) blades, upper cauline linear-oblanceolate to broadly oblong, usually obtuse; calyxlobes acuminate, viscid-pubescent; corolla 16–25 mm long, 6–9 mm broad at throat, "purple," narrow guide lines at orifice, not glandular within, exceedingly pilose at base of lower lip; anther-sacs widely divaricate, explanate, ca. as long as broad, with broad line of contact, staminode slightly exserted, strongly bearded throughout its length with long golden yellow septate hairs; capsule (and ovary) glandular-puberulent.

Red Desert of southwestern Wyoming and to the base of the Uinta Mts. in adjacent Utah. Type locality: "This is common on the Green River Desert, Wyoming, at Granger and Green River, and appears to have been first collected since the time of Nuttall by Cleburne, June 27, 1875. It is also A. Nelson's no. 4716."

WYOMING. CARBON Co.: Hanna, Payson 1691 (CAS, GH, M, NY, Ph, RM); Ft. Steele, Nelson 5384 (C, RM); Rawlins, Keck 915 (CI). FREMONT Co.: 8 mi. W. of Wind River, Costello & Rawlins 2064 (CI). SWEETWATER Co.: Green River, June 27, 1875, Cleburne (Po, type), Nelson

3052 (RM, type of P. auricomus; isotypes GH, M, NY), Nelson 4716 (CM, F, NY, Po, Pul, RM); 21 mi. W. of Green River, Payson & Armstrong 3204 (GH, M, Ph, Po, RM); Granger, June 24, 1896, Jones (Po); Burned Fork, Williams 406 (CAS, NY, RM, Utah). UTAH. DAGGETT Co.: S. of Manila, Williams 443 (NY).

This species is closely allied with P. eriantherus Pursh, the two having many characters in common. The two are separable by the smaller corolla with contracted orifice, more densely pilose lower lip, and shorter, stiffer beard of the staminode in P. Cleburnei. This species, for the most part, is lower in stature and has broader rosette leaves than P. eriantherus, giving

it a somewhat different aspect.

The two species occupy different geographical areas, but in Carbon County, Wyoming, they occur together and there the flowers of P. Cleburnei are larger than average. Also, in Big Horn County, Wyoming, a race of P. eriantherus is found that simulates P. Cleburnei in stature and flower-size, but in it the throat is broader and the staminode longerbearded. Representative of this race are: 10-15 mi. E. of Kane, Williams 3012 (CI); near summit of Big Horn Mts., Ownbey 833 (CI); Trappen Creek, on road from Shell, Finley 25 (RM).

18. Penstemon Whitedii Piper

Penstemon Whitedii Piper, Bot. Gaz. 22: 490. 1896.

Stems 1-3 or 4 dm tall, pubescent to glabrate; leaves entire to sharply toothed, glabrous to densely cinereous-puberulent, broadly linear to lanceolate or oblanceolate; calyx-lobes acute to acuminate, strongly viscid-pubescent, not additionally puberulent; corolla 18-23 mm long, 6-9 mm wide at throat, mauve to deep red-purple throughout or the lobes more indigo, guide lines of darker color within throat, not glandular within, \pm pilose at base of lower lip; anther-sacs widely divaricate, much longer than broad, not explanate, with short line of contact; staminode scarcely exserted, usually bearded with golden yellow hairs; capsule (and ovary) glandular-puberulent.

Central Washington, northeastern Oregon, and central Idaho.

KEY TO SUBSPECIES

Staminode densely bearded for almost its entire length with hairs much longer than its width. Upper cauline leaves cordate-clasping at base, mostly 3 to 4 times longer than broad; verticil-Upper cauline leaves merely sessile or even narrowed at base, mostly 5 to 8 times longer than Staminode sparsely bearded with hairs ca. equaling its width to glabrate or rarely glabrous....

18a. Penstemon Whitedii subsp. typicus, nom. nov.

Penstemon Whitedii Piper, l.c. P. eriantherus var. Whitedii A. Nels., Bot. Gaz. 54: 148. 1912. Known only from southern Chelan County, Washington. Type locality: "Collected in rocky soil near Wenatchee, Kittitas county [now Chelan County], July 7, 1896. Kirk Whited no. 131."

WASHINGTON. CHELAN Co.: Wenatchee, Whited 131 (US, type; isotype Pul), 1068 (GH, US), 1102 (NY, US), 1166 (US), 1257 (US); lower Blewett Pass, Thompson 8307 (C, Cl, M, NY, Ph, SU).

18b. Penstemon Whitedii subsp. tristis Pennell et Keck, subsp. nov.

Caulibus spithameis, foliis glaucescentibus angustis, supremis lanceolatis sessilibus, inflorescentia brevi plus minusve cum glandulis roridis, floribus et capsulis in eadem cyma accrescentibus, corolla purpurascente a basi labio infero villosissima, filamento sterili hinc longe denseque barbato.

Type: F. W. Pennell no. 15200, collected on a rocky calcareous mountain along Antelope Creek, Custer County, Idaho, at 1890 meters elevation, June 21, 1931, Academy of Natural Sciences of Philadelphia. Isotype CI.

IDAHO. LEMHI Co.: Salmon, Payson 1838 (CAS, GH, M, NY, RM), 1787 (M, RM); Salmon River, 23 mi. above Salmon, Pennell 15232 (CI, Ph). Custer Co.: Clayton, Macbride & Payson 3363 (GH, RM); Mackay, Nelson & Macbride 1421 (GH, M, F, RM), 1562 (RM); Morgan Creek, Pennell 15246 (CI, Ph). Blaine Co.: Lost River Mts., near Clyde, Macbride & Payson 3133 (GH, RM). OREGON. Wallowa Co.: Imnaha (River), Cusick 1435 (GH, Ph), Sherwood 133 (F).

18c. Penstemon Whitedii subsp. dayanus (Howell), comb. nov.

Penstemon dayanus Howell, Fl. N. W. Am. 1: 511. 1901.

P. eriantherus var. argillosus M. E. Jones, Contr. West. Bot. 12: 62. 1908. "John Day Valley, Oregon, June 6, 1902, Cusick, No. 2803." Exactly the same form that Howell had previously described.

North-central Oregon, on open dry hillsides in the drainage of the John Day and Deschutes rivers, at elevations of 300 to 1100 meters. Type locality: "Hillsides and plains, Muddy Station, John Day Valley, Oregon."

OREGON. GILLIAM Co.: Pine Creek, Leiberg 179 (GH, NY, Ph, Po, RM, US). ? Co.: Muddy Station, John Day Valley, May 12, 1885, Howell (U Oregon, type; isotype GH), the same, May 11, 1885 (Ph, Pul, US); John Day Valley, Cusick 2803 (Po, type of P. eriantherus var. argillosus; isotypes C, CI, F, GH, NY, Ph, Pul, Minn, US). Wheeler Co.: 5 mi. N. of Mitchell, Peck 10091 (F, NY); 4 mi. E. of Mitchell, Keck & Clausen 3669 (C, CAS, CI, GH, NY, Ph, Po, Pul, SU). Crook Co.: Crooked River, Cusick 1672 (C, F, M, US).

The situation in this species is somewhat unusual in that one discerns

here three geographic centers, not very closely approaching each other, and in each of which a recognizable morphological unit has appeared. These I am calling subspecies because in most respects they share common characters that strongly indicate their monophyletic origin and a continuous series of morphological variants links all the forms together. That this continuous chain of forms is geographically divisible into three parts may perhaps either be accounted for by the geological history of the region or by the comparatively modern transplantation of portions of the species into new regions. For instance, subsp. typicus appears to have a very restricted range in Chelan County, central Washington. Probably as a consequence, this unit is but little variable. On the other hand, it is very difficult to separate from certain forms of subsp. tristis, which occur no closer than the Imnaha River of northeastern Oregon. Furthermore, subspp. tristis and dayanus, which have more extensive ranges, are appreciably variable and it is this variability which ties the units together. In other words, here appear to be three elements that now possess apparent geographic isolation, but that seemingly lack a comparable structural distinctness.

Carnegie Institution of Washington Division of Plant Biology Stanford University, Calif.



INDEX TO AMERICAN BOTANICAL LITERATURE 1934-1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

This index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the Index may be addressed to the Treasurer of the Torrey Club.

- Acosta Solis, M. & Machado, S. T. Estudio botanico quimico del *Espeletia grandiflora*. Inst. Bot. Univ. Central, Ecuador. 1-62, f. 1-9. 1937.
- Adams, J. Some additional species from Anticosti Island. Cannadian Field Nat. 51: 135. 8 D 1937.
- Alexander, E. J. Centaurea macrocephala. Addisonia 20:23, 24 pl. 652. 15 N 1937.
- Alexander, E. J. Coreopsis saxicola. Addisonia 20: 17, 18. pl. 649. 15 N 1937.
- Alexander, E. J. Senecio millefolium. Addisonia 20: 31, 32. pl. 656. 15 N. 1937.
- Alexander, E. J. Senecio rugelia. Addisonia 20: 29, 30, pl. 655. 15 N 1937.
- Allan, H. H. Wild species-hybrids in the phanerogams. Bot. Rev. 3: 593-615. D 1937.
- Allen O. N. & Allen, E. K. Root-nodule bacteria of some tropical leguminous plants. I. Cross-inoculation studies with Vigna sinensis L. Soil Sci. 42: 61-76. pl. 1, 2. Jl 1936.
- Ames, O. Studies in Stelis. VI. Harvard Univ. Bot. Mus. Leafl. 4: 21-25. illust. 9 Jl 1936.
- Anderson, L. E. & Beaven, E. S. The mosses of Franklin County, North Carolina. Jour. Elisha Mitchell Sci. Soc. 53: 324-333. D 1937.
- Arnold, C. A. & Steidtmann, W. E. Pteridospermous plants from the Pennsylvanian of Illinois and Missouri. Am. Jour. Bot. 24: 644–650. f. 1–14. N 1937.
- Artz, L. Anagallis arvensis L. Claytonia 4: 21, 22. O 1937.
- Artz, L. Herbaceous plants from the vicinity of Wold Scuffold Hunt Club camp, Augusta County, Virginia, May 9, 1937. Claytonia 4: 25, 26. O 1937.
- Artz, L. Notes on Arabis lyrata L. Claytonia 4: 19-21. O 1937.
- Artz, L. Notes on Astragalus distortus. Claytonia 4: 24, 25. O 1937.

Baker, R. E. D. Notes on Trinidad fungi. I. Phytophthora. Jour. Imp. Coll. Trop. Agr. 13: 330-332. f. 1-4. D 1936.

Bannan, M. W. Observations on the distribution of xylem-ray tissue in conifers. Ann. Bot. II. 1:717-726. pl. 27. O 1937.

Barnett, J. Pollen study of Cranberry Pond near Emporia, Madison County, Indiana. Butler Univ. Bot. Stud. 4: 55-64. f. 1. N 1937.

Barrett, M. F. A leaf key to Florida broad-leaved trees. 1-79. pl. 1-8. Montclair, N. J. 1937.

Barrows, F. L. Propagation of *Lycopodium*. III. Spore germination. Contr. Boyce Thompson Inst. 8: 233-236. Jl-S 1936.

Benatar, R. Contribuição ao estudo e tratamento das mais communs doenças de roseiras. Rodriguesia 2: 9-23. f. 1-13. Mr-Je 1937.

Berdan, H. Observations on the reproduction of Ancylistes. Jour. Elisha Mitchell Sci. Soc. 53: 343-344. D 1937.

Berkeley, G. H. Studies in fruit diseases. II. Diseases of plums and their control. Canada Dep. Agr. Circ. 114: 1-10. Au 1936.

Bernath, E. L. Coniferous forest trees of Chile. Trop. Woods 52: 19-26. 1 D 1937.

Berry, E. W. *Gyrocarpus* and other fossil plants from the Cumarebo field in Venezuela. Jour. Washington Acad. Sci. 27: 501-506. 15 D 1937.

Berry, E. W. On the presence of the fern Weichselia in Colombia, South America. Jour. Washington Acad. Sci. 27: 458-461. 15 N 1937.

Biggs, R. The species concept in *Corticium coronilla*. Mycologia 29: 686-706. f. 1-26. 1 D 1937.

Billings, F. H. Some new features in the reproductive cytology of angiosperms illustrated by *Isomeris arborea*. New Phytol. 36: 301–326. f. 1–52. 29 O 1937.

Blakeslee, A. F., Bergner, A. D. & Avery, A. G. Geographical distribution of chromosomal prince types in *Datura stra-monium*. Cytologia Fujii 1070-1093. f. 1-6. 1937.

Blank, L. M. Fusarium resistance in Wisconsin all seasons cabbage. Jour. Agr. Res. 55: 497-510. f. 1-4. 1 O 1937.

Blossfeld, H. Eine Kakteen-Sammelreise im Südamerika. V. Kakteenkunde 1936: 110–112. illust. Je 1936.

Bonisteel, W. J. Aconitum noveboracense. Addisonia 20: 19-20. pl. 650. 15 N 1937.

Bonner, J. The rôle of vitamins in plant development. Bot Rev. 3: 616-640. D 1937.

- Braun, E. L. Notes on Kentucky plants. I. Jour. So. Appalachian Bot. Club 1: 41-45. Ap 1936.
- Briggs, F. N. & Barry, G. L. Inheritance of resistance to mildew, Erysiphe graminis hordei, in a cross of Goldfoil and Atlas barleys. Zeits. Zuchtung 22:75-80. N 1937.
- Brooks, W. G. Orchids and cacti. Jour. Cactus & Succ. Soc. Am. 9: 77-78. N 1937.
- Brown, J. G. Relation of livestock to the control of *Sclerotinosis* of lettuce. Phytopathology 27: 1045-1050. f. 1. N 1937.
- Brown, N. E. & Gardner, F. E. Indoleacetic acid galls of a secondary type. Phytopathology 27: 1110-1113. f. 1, 2. N 1937.
- Brown, R. W. Further additions to some fossil floras of the western United States. Jour. Washington Acad. Sci. 27: 506-517. f. 1. 15 N 1937.
- Burns, G. P. Studies in tolerance of New England trees. XIII.

 The effect of root development on height and diameter growth. Vermont Agr. Exp. Sta. Bull. 422: 1-29. f. 1-5.

 My 1937.
- Bushnell, O. A. & Sarles, W. B. Studies on the root-nodule bacteria of wild leguminous plants in Wisconsin. Soil Sci. 44: 409-423. D 1937.
- Buxbaum, F. Zur Kenntnis der natürlichen Standortsverhältnisse der Katkeen. II. Kakteenkunde 2: 27–28. F 1937; III. Kakteenkunde 4: 55. Ap 1937. IV. 7: 102–104. illust. II 1937.
- Buy, H. G. du & Olson, R. A. The presence of growth regulators during the early development of *Fucus*. Am. Jour. Bot. 24: 609-611. N 1937.
- Camp, W. H. Dicentra cucullaria. Addisonia 20: 21, 22. pl. 651.

 15 N 1937.
- Campbell, I. Further data on monosporous cultures of Gelasinospora tetrasperma. Bull. Torrey Club 64: 583-586. f. 1, 2. 9 D 1937.
- Carr. L. G. Utriculariaceae of Augusta County. Claytonia 4: 23, 24. O 1937.
- Chandler, C., Porterfield, W. M. & Stout, A. B. Microsporogenesis in diploid and triploid types of *Lilium tigrinum* with special references to abortions. Cytologia Fujii 756-784. pl. 24-26. f. 1-11. 1937.
 - Cheesman, E. E. Specific and varietal susceptibility of bananas to *Cercospora* leaf spot. Jour. Imp. Col. Trop. Agr. 14: 335, 336. D 1937.

- Cholodny, N. Charles Darwin and the modern theory of tropism. Science II 86: 468. 19 N 1937.
- Clarke, S. H. A comparison of certain properties of temperate and tropical timbers. Trop. Woods 52: 1-11. 1 D 1937.
- Clausen, R. T. Najas gracillima in Indiana and Michigan. Rhodora 39: 432. N 1937.
- Conzatti, C. Flora taxonomica Mexicana. Mexico Forestal 14: (Suppl.) 7-11. S-O 1936. 15: (Suppl.) 17-20 Ja-F 1937; 21-24. Mr-Ap 1937; 15: (Suppl.) 25-28. My-Jl 1937.
- Cooper, D. C. Macrosporogenesis and embryo-sac development in Euchlaena mexicana and Zea Mays. Jour. Agr. Res. 55: 539-551. f. 1-4. 1 O 1937.
- Cormack, M. W. Fusarium spp. as root parasites of alfalfa and sweet clover in Alberta. Canadian Jour. Res. 15: 493-510. f. 1, 2. N 1937.
- Couch, J. N. The formation and operation of the traps in the nematode-catching fungus, *Dactylella bembicodes* Dreschler. Jour. Elisha Mitchell Sci. Soc. 53: 301-309. pl. 27. D 1937.
- Couch, J. N. A new fungus intermediate between the rusts and Septobasidium. Mycologia 29: 655-673. f. 1-25. 1 D 1937.
- Croizat, L. On the classification of *Euphorbia*. II. How should the cyathium be interpreted? Bull. Torrey Club 64: 523-536. N 1937.
- Culpepper, C. W. The composition of the aerial parts of the summer squash (*Cucurbita Pepo*) at different stages of development. Am. Jour. Bot. 24: 565-573. N 1937.
- Curtis, H. J. & Cole, K. S. Transverse electric impedance of Nitella. Jour. Gen. Physiol. 21: 189-201. f. 1-4. 20 N 1937.
- Dale, E. E. A series of multiple alleles especially affecting the corolla in Salpiglossis. Am. Jour. Bot. 24: 651-656. f. 1-16. N. 1937.
- Day, D. & Comboni, S. Effects of potassium deficiency on the formation of starch in *Pisum sativum*. Am. Jour. Bot. 24: 594-597. N 1937.
- Dickson, J. Studies in floral antomy. III. An interpretation of the gynoeceum in the Primulaceae. Am. Jour. Bot. 23: 385-393. f. 1-9. Je 1936.
- Dimock, A. W. Hybridization experiments with natural variants of *Hypomyces Ipomoeae*. Bull. Torrey Club. 64: 499–506. f. 1. N 1937.
- Dodge, B. O. The conidial stage of *Peziza pustulata*. Mycologia 29: 651-655. f. 1. 1 D 1937.

- Dodge, B. O. The perithecial cavity formation in a Leptosphaeria on Opuntia. Mycologia 29: 707-716. f. 1, 2. 1 D 1937.
- Dodge, B. O. Spindle orientation and spore delimitation in Gelasinospora tetrasperma. Cytologia Fujii 877-887. pl. 32, 33. 1937.
- Dodge, C. W. & Dodge, B. S. Some effects of methyl cholanthrene on the morphology and growth of yeasts. Ann. Missouri Bot. Gard. 24: 583-590. pl. 34. 23 N 1937.
- Drouet, F. Notes on the flora of Columbia, Missouri. III. Rhodora 38: 191-195. My 1936.
- Drouet, F. Some Myxophyceae from the Canal Zone. Bull. Torrey Club 64: 599-604. f. 1-3. 9 D 1937.
- Ducke, A. Notes on the Myristicaceae of Amazonian Brazil, with descriptions of new species. II. Jour. Washington Acad. Sci. 26: 253-264. 15 Je 1936.
- Dyer, R. A. Botanical exploration in South Africa. Jour. Cactus & Succ. Soc. Am. 9: 68-70. illust. N 1937.
- Eastwood, A. New species of western plants. Leafl. West. Bot. 2: 54-56. 20 N 1937.
- Eastwood, A. Notes on *Schizococcus*, with a key to the species. Leafl. West. Bot. 2: 49-50. 20 N 1937.
- Edwards, J. K. Cytological studies of toxicity in meristem cells or roots of *Zea Mays*. I. The effects of the neutral salts. Am. Jour. Bot. 23: 483-489. f. 1-13. Jl 1936.
- Emerson, F. W. A botanical survey of Big Basin in the Allegany State Park. N. Y. State Mus. Handbook 17:89-150. f. 31-55. 1937.
- Everett, T. H. Ochna serrulata. Addisonia 20: 27-28. pl. 654. 15 N 1937.
- Ewan, J. Bibliographical miscellany. II. Torreya 36: 25-28. Mr-Ap 1936.
- Fernald, M. L. Local plants of the inner coastal plain of south-eastern Virginia. Rhodora 39: 321-366. S 1937; 379-415. pl. 474-481. O 1937; 433-459. pl. 482-487. N 1937; 465-491. D 1937.
- Flemion, F. After-ripening at 5°C favors germination of grape seeds. Contr. Boyce Thompson Inst. 9: 7-15. Jl-S 1937.
- Foster, R. C. A cyto-taxonomic survey of the North American species of *Iris*. Contr. Gray Herb. Harvard Univ. 119: 1-82. pl. 1-3. 12 N 1937.
- Freeman, F. L. The variations of *Psoralea psoralioides*. Rhodora 39: 425-428. N. 1937.
- Giersbach, J. Germination and seedling production of Arctosstaphylos Uva-ursi. Contr. Boyce Thompson Inst. 9: 71-78. f. 1. O-D 1937.

- Giersbach, J. Germination and seedling production of species of *Viburnum*. Contr. Boyce Thompson Inst. 9: 79-90. f. 1-4. O-D 1937.
- Giersbach, J. Some factors affecting germination and growth of gentian. Contr. Boyce Thompson Inst. 9: 91-103. f. 1, 2. O-D 1937.
- Goodspeed, T. H. Significance of cytogenetic alterations induced by high frequency radiation in *Nicotiana* species. Cytologia Fujii. 961–966. 1937.
- Goodwin, R. H. Studies on the seedling development of Solidago rugosa Mill., S. sempervirens L. and the reciprocal hybrids between them. Am. Jour. Bot. 24: 627-640. f. 1-16. N 1937.
- Gordon, R. B. The botanical survey of the Allegany State Park. N. Y. State Mus. Handbook 17: 23-88. f. 1-30. 1937.
- Gordon, R. B. A botanical survey of the northern section of the Allegany State Park. N. Y. State Mus. Handbook 17: 287-328. f. 163-192. 1937.
- Gordon, R. B. A botanical survey of the southwestern section of the Allegany State Park. N. Y. State Mus. Handbook 17:199-247. f. 91-130. 1937.
- Gordon, R. B. The relation of vegetational surveys to a state park management policy. N. Y. State Mus. Handbook 17: 329-382. 1937.
- Grace, N. H. Physiologic curve of response to phytohormones by seeds, growing plants, cuttings, and lower plant forms. Canadian Jour. Res. 15: 538-546. f. 1-15. N 1937.
- Grøntved, J. Vascular plants from Arctic North America collected by the Fifth Thule Expedition 1921-24. Rep. Fifth Thule Exp. 1921-24. 2: 1-93. map. 1936.
- Gustafson, F. G. & Darken, M. Further evidence for the upward transport of minerals through the phloem of stems. Am. Jour. Bot. 24: 615-621. f. N 1937.
- Guthrie, J. D. Factors influencing the development of ascorbic acid and glutathione in potato tubers following treatment with ethylene chlorhydrin. Contr. Boyce Thompson Inst. 9:17-39.f. 1. JI-S 1937.
- Happ, G. B. Monograph of Tetramerium and Henrya. Ann. Missouri Bot. Gard. 24: 501-582. pl. 27-33. f. 1. 23 N 1937.
- Harger, E. B. Some noteworthy plants of Tennessee. Rhodora 39: 428-432. N 1937.
- Harrar, E. S. Notes on the genus Flindersia R. Br. and the systematic anatomy of the important Flindersian timbers indigenous to Queensland. Jour. Elisha Mitchell Sci. Soc. 53: 282-291. pl. 24-26. D 1937.

- Harris, S. A. & Thompson, H. J. Pectic acid from the cotton fiber. Contr. Boyce Thompson Inst. 9: 1-5. Jl-S 1937.
- Hasselman, C. F. Contribucao ao estudo da flora mycologica do Itatiaya. Rodriguesia 2: 55-58. O 1937.
- Hermann, F. J. Extensions of range and a new species in *Carex*. Rhodora 39: 491-495. D 1937.
- Hermann, F. J. Notes on the flora of Michigan. I. Rhodora 38: 362-367. O 1937.
- Herre, H. Two fine and little-known species of Argyroderma. Desert 9: 112, 113. illust. O-N 1937.
- Hicks, L. E. A botanical survey of the eastern section of the Allegany State Park, New York, N. Y. State Mus. Handbook 17: 249-286. f. 131-162. 1937.
- Hill, A. F. Economic botany. i-x, 1-502. f. 1-225. New York. McGraw-Hill Book Co. 1937.
- Hirschhorn, E. Nota critica sobre una Ustilaginacea Argentina. Rev. Argentina Agron. 4: 168–170. f. 1–3. S 1937.
- Hopkins, E. F. & Phillips, J. K. Temperature and starch-sugar change in sweet potatoes. Science II 86: 523-525. 3 D 1937.
- Horta, P. P. Uma nova orchidacae da Amozonia. Rodriguesia 2: 25-28. pl. 1, 2. Mr-Je 1937.
- Howell, J. T. A collection of Douglas' western American plants. I. Leafl. West. Bot. 2: 59-62. 20 N 1937.
- Howell, J. T. A remarkable new *Phacelia*. Leafl. West. Bot. 2: 51-52. 20 N 1937.
- Huskins, C. L. The internal structure of chromosomes—a statement of opinion. Cytologia Fujii. 1015–1022. pl. 36, 37. 1937.
- Jeffrey, E. C. The somatic chromosomes of *Trillium*. Cytologia Fujii. 857–866. f. 1-4. 1937.
 - Jenkins, A. E. Coryneum microstictum on rose from Oregon. Mycologia 29: 725-731. f. 1, 2. 1 D 1937.
 - Johnson, J. Ismé Aldyth Hoggan. Phytopathology 27: 1029–1032. Portrait. N 1937.
 - Johnson, J. Relation of water-soaked tissues to infection by *Bacterium angulatum* and *Bact. tabacum* and other organisma. Jour. Agr. Res. 55: 599-618. f. 1-14. 15 O 1937.
 - Johnson, L. P. V. & McLennan, A. Hybridization of *Triticum* and *Agropyron*. III. Canadian Jour. Res. 15: 511-519. N 1937.
 - Jones, K. L. Studies on Ambrosia. I. The inheritance of floral types in the ragweed, Ambrosia elatior L. Am. Midl. Nat. 17: 673-699. f. 1-31. Jl 1936.

- Josserand, M. & Smith, A. H. Notes on the synonymy of French and American agarics. I. Mycologia 29: 717-724. 1 D 1937.
- Kemp, W. B. Natural selection within plant species. Jour. Heredity 28: 329-333. f. 1-4+frontispiece. O 1937.
- Kenoyer, L. A. A botanical survey of a portion of Allegany State Park from Allegheny River to road along upper Red House Creek and from Bay State road to Quaker Run road. N. Y. State Mus. Handbook 17: 151-197. f. 56-90. 1937.
- Killip, E. P. New plants mainly from western South America. V. Jour. Washington Acad. Sci. 26: 358-360. 15 S 1936.
- Kinsel, K. Carbohydrate utilization by the corn Diplodias. Phytopathology 27: 1119-1120. N 1937.
- K[OHL]P.A. New or noteworthy plants for St. Louis. XII. Missouri Bot. Gard. Bull. 25: 140-145. pl. 21+f. 1. O 1937.
- Krukoff, B. A. & Smith, A. C. Rotenone-yielding plants of South America. Am. Jour. Bot. 24: 573-587. f. 1-5. N 1937.
- La Rue, C. D. Intumescences on poplar leaves, III. The rôle of plant growth hormones in their production. Am. Jour. Bot. 23: 520-524. O 1936.
- Lee, M. H. Ariocarpus. Jour. Cactus & Succ. Soc. Am. 9:71-77. illust. N 1937.
- Linder, D. H. New Venezuelan fungi imperfecti. Mycologia 29: 656-664. f. a-f. 1 D 1937.
- Lipman, C. B. Tolerance of liquid air temperatures by spore-free and very young cultures of fungi and bacteria growing on agar media. Bull. Torrey Club 64: 537-546. f. 1. N 1937.
- Long, F. R. Euphorbias of Port Elizabeth. Jour. Cactus & Succ. Soc. Am. 9: 51-53. illust. O 1937.
- Lundell, C. L. New plants from the Yucatan peninsula. Bull. Torrey Club. 64: 547-556. N 1937.
- Lundell, C. L. Studies of Mexican and Central American plants. IV. Field & Lab. 6: 9–16. N 1937.
- MacLaughlin, E. H. Studies on *Phytolacca decandra*. I. Morphology of young inflorescence. Am. Jour. Pharm. 108: 90-94. f. 1-6. Mr 1936.
- Macbride, J. F. Flora of Peru. VI. Field Mus. Nat. Hist. Bot. Ser. 13: 265-491. 29 O 1937.
- McMurtrey, J. E. Cross transfer of mineral nutrients in the tobacco plant. Jour. Agr. Res. 55: 475-482. f. 1-4. 1 O 1937.

- Mains, E. B. A new species of *Cordyceps* with notes concerning other species. Mycologia 29: 674-677. f. 1, 2. 1 D 1937.
- Maneval, W. E. A list of Missouri fungi with special reference to plant pathogens and wood-destroying species. Univ. Missouri Stud. 12: 1-150. 1 Jl 1937.
- Manza, A. V. New species of articulated corallines from South Africa. Proc. Nat. Acad. Sci. 23: 568-572. 15 N 1937.
- Manza, A. V. Some north Pacific species of articulated corallines. Proc. Nat. Acad. Sci. 23: 561-567. 15 N 1937.
- Marvin, J. W. Cell shape phenomena interpreted in terms of compressed lead shot. Science II. 86: 493, 494. 26 N 1937.
- Merrill, E. D. Aphanomyrtus Miquel and Pseudoeugenia Scortechini. Blumea Suppl. 1: 107-111. 1937.
- Merrill, E. D. Domesticated plants in relation to the diffusion of culture. In Early Man. 277-284. 1937.
- Merrill, E. D. Razumovia Sprengel versus Centranthera R. Brown. Bull. Torrey Club 64: 589-598. 9 D 1937.
- Meyer, T. Los arboles indigenas de importancia del Departamento de resistencia (chaco). Rev. Argentina Agron. 4: 153-167. S 1937.
- Miller, J. C. Inducing the sweet potato to bloom and set seed. Jour. Heredity 28: 347-349. f. 8, 9. O 1937.
- Moldenke, H. N. A monograph of the genus *Petitia*. Repert, Spec. Nov. 42: 229-251. 25 N 1937.
- Moreland, C. F. Natural paper formed by dried algae. Am. Jour. Bot. 24: 592-593. f. 1-6. N 1937.
- Muller, C. H. Plants as indicators of climate in northeast Mexico. Am. Midl. Nat. 18: 986-1000. f. 1-16. N 1937.
- Nebel, B. R. Chromosome structure. X. An X-ray experiment. Genetics 21: 605-614. f. 1-3. S 1936.
- Nolla, J. A. B. Inheritance in *Nicotiana*. II. The conception of reaction system contrasts in heredity. Jour. Heredity 27: 121-126. f. 15, 16. Mr 1936.
- Olson, R. A. & du Buy, H. G. The rôle of growth substance in the polarity and morphogenesis of *Fucus*. Am. Jour. Bot. 24: 611-615. f. 1-3. N 1937.
- O'Neill, H. Notes on western plants. Leafl. West. Bot. 2: 20 N 1937.
- Osborn, H. T. Vein-mosaic virus of red clover. Phytopathology 27: 1051-1058. f. 1-3. N 1937.
- Osterhout, W. J. V. The protoplasmic surface in certain plant cells. Trans. Faraday Soc. 33: 997-1002. Au 1937.
- Osterhout, W. J. V. Some ways to control bioelectrical behavior. Cold Spring Harbor Symp. Quant. Biol. 4: 43-52, 1936.

- Panshin, A. J. Wood anatomy of certain South American rotenone-yielding plants. Am. Jour. Bot. 24: 587-591. f. 1-10. N 1937.
- Peattie, D. C. Additions, corrections, and deletions for the flora of the Tryon region. Jour. Elisha Mitchell Sci. Soc. 53: 311-323. D 1937.
- Peebles, R. H. A new species of *Opuntia* series Dillenianae. Jour. Cactus & Succ. Soc. 9: 67, 68. illust. N 1937.
- Pfeiffer, H. Conspectus Cyperacearum in America meridionali nascentium. Report Spec. Nov. 42: 252-256. 25 N 1937.
- Pittier, H. Notas dendrologicas de Venezuela. Bol. Soc. Venezuela. Cien. Nat. 3: 423-436. 1937.
- Poellnitz, K. von. Six new species of *Haworthia Duval*. Desert 9: 102, 103. f. 1-8. S 1937.
- Polunin, N. Vascular plants from Diana Bay, Hudson Strait. Canadian Field Nat. 51: 111-114. 1 N 1937.
- Potzger, J. E. Vegetative reproduction in conifers. Am. Midl. Nat. 18: 1001-1004. f. 1, 2. N 1937.
- Prettyman, R. L. Fossil pollen analysis of Fox Prairie bog, Hamilton County, Indiana. Butler Univ. Bot. Stud. 4: 33-42. f. 1 N 1937.
- Purpus, C. A. Begonia incana. Desert 9: 100. S 1937.
- Raup, H. M. Phytogeographic studies in the Athabaska-Great Slave Lake region. Jour. Arnold Arbor. 17: 180-240. pl. 190-194. Jl 1936.
- Rendle, B. J. Gelatinous wood fibres. Trop. Woods 52: 11-19.
 1 D 1937.
- **Rendle, A. B.** Notes on the flora of Jamaica. Jour. Bot. 75: 347-351. f. 1-3. D 1937.
- Rich, P. J. Uma nova especie de Agaricacea. Rodriguesia 2: 46, 47. f. 1. O 1937.
- Ritchie, D. The morphology of the perithecium of Sordaria fimecola (Rob.) Ces. and DeNot. Jour Elisha Mitchell Sci. Soc. 53: 334-342. pl. 18, 29. D 1937.
- Roberts, H. F. The causes of autumn coloration. Sci. Monthly 45: 427-435. illust. N 1937.
- Robertson, D. W. Factors affecting chlorosis in irrigated wheat. Jour. Agr. Res. 55: 511-520. f. 1, 2. 1 O 1937.
- Rodenhiser, H. A. & Holton, C. S. Physiologic races of *Tilletia Tritici* and *T. levis*. Jour. Agr. Res. 55: 483-496. 1 O 1937.
- Rodrigues, J. B. Orchidaceas novas de Barbosa Rodrigues. Rodriguesia 2: 37-40. pl. 35, 36. O 1937.
- Rollins, R. C. Two new species of Arctostophylos from the Rocky Mountains. Rhodora 39: 462-464. N 1937.

DIRECTORY OF DEALERS

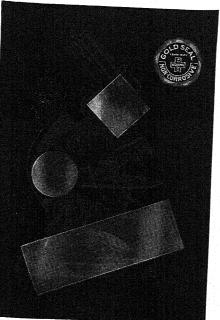
IN MATERIALS OF SCIENCE

The firms listed in this section represent reputable dealers in materials for the laboratory, library, greenhouse, field and garden.

Before you make your purchases consult these firms.

You are assured of courteous treatment and an ample discount.

Mention the BULLETIN





The Standard for Microscope Glass

Gold Seal Microscope Slides and Cover Glasses

Crystal Clear · Non-Corrosive · Will Not Fog

Gold Seal Slides and Cover Glasses attain a precise uniformity of thinness and plane surface that is unparalleled. They are brilliantly crystal clear and guaranteed against corrosion, fogging or any imperfection. Microscopic work deserves the best—specify Gold Seal Slides and Cover Glasses.



Thiamin and growth of species of Phytophthora¹

WILLIAM J. ROBBINS (WITH TWO FIGURES)

Since the demonstration of the necessity of thiamin (vitamin B₁) for the growth of *Phycomyces Blakesleeanus* by Schopfer (11) the relation of this vitamin and its pyrimidine and thiazole intermediates to the growth of a number of fungi has been reported. Thiamin hydrochloride has the following structure:

It was synthesized by Williams and Cline (15) from a pyrimidine and a thiazole of the following composition:

2-methyl-5-bromomethyl-6-aminopyrimidine hydrobromide

$$\begin{array}{c|c} N=&C-NH_2\cdot HBr\\ \hline \\ CH_3-C & C-CH_2Br\\ \hline \\ N-&C \\ \hline \\ H \end{array}$$

4-methyl-5 β hydroxyethylthiazole

¹ The author gratefully acknowledges the assistance of Frederick Kavanagh and Frederick C. Robbins.

[The Bulletin for April (65: 211-265) was issued April 1, 1938]

267

BULLETIN OF THE TORREY BOTANICAL CLUB, Vol. 65, No. 5, May, 1938

It was found that *Phycomyces Blakesleeanus* grows satisfactorily in a medium containing the two intermediates instead of the vitamin (7, 12, 13) and that the growth of *Phycomyces* is not, therefore, conclusive evidence of the presence of thiamin. In fact, it appears that *Phycomyces* actually requires thiamin and though capable of forming it from the two intermediates, it is unable to synthesize either intermediate from the mineral salts, sugar and asparagine which constitute the basic medium (7). Other fungi which grow poorly or not at all on a medium of mineral salts, sugar and asparagine are able to synthesize the vitamin thiazole but little or none of the intermediate pyrimidine (8). These organisms require for growth an external supply of the pyrimidine. Still others synthesize pyrimidine but little or no thiazole and require the latter compound (6). None of these organisms can be said to require an external supply of thiamin since they grow satisfactorily if furnished with one or both of the intermediates.

Are there fungi which require an external supply of thiamin and are incapable of using the intermediates? From our investigations we have concluded that several species of *Phytophthora*, probably most of this genus belong to such a group (9).

METHODS AND MATERIALS

The following species of *Phytophthora* kindly furnished by C. M. Tucker were used:

Phytophthora Boehmeriae Saw., P. cactorum (L. and C.) Schwet., P. cambivora (Petri) Buis., P. capsici Leon., P. cinnamomi Rands, P. citrophthora (Sm. and Sim.) Leon., P. cryptogea Pethyb. and Loff., P. Dreschsleri Tuck., P. fagopyri Takemoto, P. palmivora Butler, and P. parasitica. Dast.

The fungi were grown in 25 ml. of liquid medium in 150 ml. Erlenmeyer flasks of pyrex glass at room temperature (18–24° C). The media were sterilized at 110° C for 20 minutes unless otherwise noted. The stock cultures were grown on oatmeal agar or potato dextrose agar. A bit of mycelium, a millimeter or two in diameter was used as inoculum, care being taken to avoid including any of the agar of the stock cultures with the inoculum. The commercial asparagine was purified for some experiments by repeated solution in water and precipitation with alcohol. The thiamin was Merck's synthetic betabion; the thiazole was 4-methyl-5-hydroxyethylthiazole and the pyrimidine, 2-methyl-5-bromomethyl-6-aminopyrimidine hydrobromide. Both the latter compounds were generously supplied by Merck and Co. through the courtesy of R. R. Williams.

The amount of thiamin or its intermediates added per flask is expressed in units. One unit is 10^{-9} Mole. All cultures were grown in triplicate.

Two basic media were employed: solution C, consisting of 0.5% MgSO₄·7H₂O, 1.5% KH₂PO₄, 0.05% NH₄NO₃, 1.5% asparagine and 5% dextrose; solution D which contained per liter 1 g KNO₃, 1 g NH₄NO₃, 0.5 g KH₂PO₄, 0.25 g MgSO₄·7H₂O, 25 g dextrose and Steinberg's mineral supplements (14) as follows: 0.02 ppm. Mo, 0.05 ppm. Fe, 0.04 ppm. Cu, 0.18 ppm. Zn and 0.02 ppm. Mn.

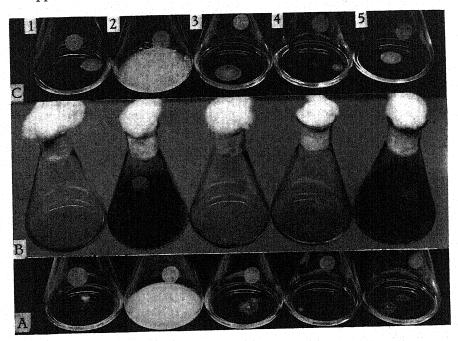


Fig. 1. Fungi grown in, (1) solution C and the same solution plus, (2) 30 units thiamin, (3) 30 units thiazole, (4) 30 units bromo-pyrimidine; (5) 30 units thiazole and 30 units bromo-pyrimidine. A = Phytophthora cinnamomi, B = Phycomyces Blakeslee-anus, C = Phytophthora Boehmeriae.

EXPERIMENTAL

When these species of *Phytophthora* were grown in (1) solution C, in solution C supplemented with (2) 30 units of thiamin, (3) 30 units of thiazole, (4) 30 units of pyrimidine or (5) a mixture of 30 units of each of the two intermediates the following results were obtained:

P. cactorum, P. citrophthora and P. palmivora showed little growth in solution C or in solution C supplemented with one or both of the intermediates. In the thiamin solutions, however, all three grew slowly but continuously and at the end of a month had formed heavy colonies from 1.5 to 3 cm. in diameter. The dry weight of the mycelium from thiamin cul-

tures of *P. citrophthora* at the end of 51 days was 154 mg., while that in solution C or solution C supplemented with thiamin intermediates averaged 4.0 mg. *P. Boehmeriae*, *P. capsici*, *P. cinnamomi* and *P. parasitica* also failed to grow appreciably in the solutions lacking thiamin; they grew (more rapidly than the species already referred to) in the solutions which contained thiamin.

At the end of a month the colonies of *P. Boehmeriae* in the thiamin solution nearly filled the liquid and their average dry weight was 179.0 mgms. (fig. 1). Those in the solutions lacking thiamin were from 0.5 to 1.0 cm. in diameter and averaged 7.2 mg. The colonies of *P. capsici* also had filled the liquid of the thiamin cultures and averaged 419.6 mg. in dry weight. In the solutions lacking thiamin the colonies ranged from 0.5 to 1.0 cm. in diameter and averaged 0.3 mg. in dry weight.

P. cinnamomi grew rapidly in the solutions containing thiamin and the average dry weight after 30 days was 547.2 mg. In the solutions lacking thiamin the colonies ranged from 0.5 to 1.5 cm. in diameter and averaged 1.2 mg. (fig. 1). P. parasitica also grew in the thiamin solutions attaining an average dry weight of 114.2 mg. while in the solutions lacking thiamin the average dry weight was 0.4 mg. P. fagopyri grew well in the solutions containing thiamin, those containing pyrimidine and those containing the mixture of pyrimidine and thiazole (8). Little or no growth developed in solution C or solution C supplemented with thiazole.

From this experiment it appeared that the growth of at least seven species of *Phytophthora* was markedly improved by the addition of thiamin to the basic solution and but little affected by the addition of the intermediates singly or together. *P. fagopyri* differed from the other species in requiring for satisfactory growth thiamin or its intermediate pyrimidine. It appeared probable that the vitamin was the effective agent because we had used in some of the cultures thiamin which had been filtered sterile; this eliminated the possibility that the vitamin had been split into its intermediates in the sterilization.

It might be suggested, however, that the failure of these organisms to grow satisfactorily in the solutions containing the intermediates was the result of their toxicity at the concentrations used (30 units in 25 ml. solution); not to the inability of the fungi to utilize them.

Two species, *P. capsici* and *P. cinnamomi*, were, therefore, grown in (1), solution C and in the same solution supplemented with (2), 5 units of thiamin; (3), 5 units of thiamin and 30 units of thiazole; (4), 5 units of thiamin and 30 units of pyrimidine; (5), 5 units of thiamin and 30 units of both the thiazole and pyrimidine. The thiamin was filtered sterile and added to the solutions which had been sterilized by heat. Both species

grew rapidly in the solutions containing thiamin and no significant difference was observed between the growth in the presence of the thiamin alone and that in the solutions containing thiamin and its intermediates. This is shown by the dry weight of the mycelium in table 1. The growth in the solutions without thiamin was slight, probably at the expense of material present in the inoculum. In all other solutions it was heavy, the differences between the various solutions containing thiamin falling within the range of probable error.

The more rapid growth in this experiment was because purified asparagine was used in place of the commercial product. Some samples of the latter were found to contain injurious materials and even traces of thiamin or its intermediates. In order to eliminate the effect of the asparagine entirely solution D was used.

TABLE 1

Dry weights of mycelium per flask in solution C and in solution C supplemented with thiamin and its intermediates. Period of growth for P. cinnamomi 9 days, and for P. capsici 16 days.

SOLUTION	DRY WT. (MG.) MTCELIUM IN SOLUTION C PLUS				
ORGANISM	Nothing	5 units thiamin	5 units thiamin 30 units thiazole	5 units thiamin 30 units pyrimidine	5 units thiamin 30 units each thiazole and pyrimidine
P. cinnamomi	0.3	334	264	302	297
P. capsici	2.0	152	166	160	178

The various species of *Phytophthora* were grown in (1), solution D and in solution D supplemented with (2), 5 units thiamin; (3), 5 units thiazole; (4), 5 units pyrimidine; (5), 5 units of both thiazole and pyrimidine, and in (6), the sugar solution without mineral salts or supplements. All species, except *P. fagopyri*, grew very little in solution D or in the solutions supplemented with one or both intermediates. The growth in the sugar solution was somewhat less than that in solution D. The growth in the thiamin solutions was several times that in solution D or solution D supplemented with one or both intermediates, though not nearly as great as in solutions containing asparagine. The dry weights are given in table 2.

The growth of *P. fagopyri* was about the same in solution D plus thiamin, plus pyrimidine or plus both intermediates (7 to 12 mg.) and distinctly more than in solution D, solution D plus thiazole or the sugar solution alone (3 to 4 mg.).

A compound resembling vitamin B₁ was secured through the courtesy of Andrew Bowman of Oxford University. As shown by the structural

TABLE 2

Dry weight of mycelium per flask in solution D plus 5 units of thiamin and in the same solution plus one or both intermediates or no supplements.

	DRY WT. MG. IN 8		
ORGANISM	Thiamin	Pus intermediates or no supplement	PERIOD OF GROWTH DAYS
P. Boehmeriae	11.0	1	35
P. cactorum	6.0	1.5	27
$P.\ cambivora$	4.0	0.5	35
P. capsici	18.0	4.0	27
P. cinnamomi	52.0	5.0	27
P. citrophthora		not weighed	
P. cryptogea	41.0	$0.\overline{3}$	35
P. Drechsleri	28.0	3.0	27
P. palmivora	11.0	0.3	35
P. parasitica	10.0	0.5	35

formula below the thiazole portion of the compound is identical with the vitamin thiazole but the pyrimidine portion is not.

Bowman's compound is ineffective as a substitute for thiamin. Phycomyces, however, is apparently able to split it into its components (10) and to combine the thiazole thus secured with a vitamin pyrimidine to form the essential thiamin (fig. 2). If we are correct in assuming that the species of Phytophthora studied here (except P. fagopyri) are unable to synthesize thiamin from its intermediates, then Bowman's compound with or without added vitamin pyrimidine should be ineffective. We have tested this hypothesis with one species only.

P. cinnamomi grew well in solution C supplemented with 5 units of thiamin, attaining a dry weight of 227 mg. in 11 days. In solution C, in solution C supplemented with 5 units of Bowman's compound or with 5 units of Bowman's compound and 10 units of the bromopyrimidine, little or no growth occurred. In the latter solutions the dry weight of the mycelium averaged between 0.3 and 0.9 mg. (fig. 2). The thiamin and Bowman's

compound were filtered sterile and added to the solutions which had been sterilized with heat.

DISCUSSION

Ten of the eleven species of *Phytophthora* studied apparently required an external supply of thiamin and were unable to utilize the intermediates of the vitamin. It appears that these fungi are unable to synthesize the vitamin from its intermediates as *Phycomyces Blakesleeanus* seems to do readily. The synthesis of the vitamin from its intermediates may be enzy-

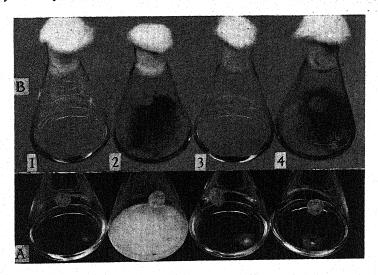


Fig. 2. Fungi grown in, (1) solution C and the same solution plus, (2) 5 units thiamin; (3) 5 units Bowman's compound; (4) 5 units Bowman's compound plus 10 units bromopyrimidine. A = Phytophthora cinnamomi, B = Phycomyces Blakesleeanus.

matic and these organisms may lack the necessary enzyme. Phytophthora fagopyri, on the other hand, seems able not only to synthezise thiamin from its intermediates but to form one of the intermediates from the more elementary materials of the medium (8). In view of the marked difference between the physiology of this species and the others studied, the question may be asked whether P. fagopyri is correctly placed in the genus Phytophthora.

Our results show that various species of *Phytophthora* are able to grow slowly in a medium which lacks organic nitrogen if the medium is supplemented by thiamin. Kögl and Fries (1) found similar results with *P. cactorum*. Reports that organic nitrogen (peptone for example) are required by these fungi and that inorganic nitrogen is unavailable are probably because the peptone supplies thiamin. Nevertheless, we secured much

greater growth in media containing asparagine than in one containing inorganic nitrogen only.

Our experience leads us to suggest that for work of the type discussed here commercial samples of asparagine should be purified. Repeated solution in water and precipitation with alcohol may be used. Unless precautions are taken with the asparagine erroneous conclusions may be drawn either because of the presence of toxic contaminants or because of the presence of appreciable amounts of thiamin or its intermediates.

Leonian (2, 3, 4, 5) was of the opinion that the accessory factor required by *P. cactorum* was not thiamin because his preparations were still active when treated in such a way as to destroy the vitamin molecule. It was thought that perhaps Leonian's results could be explained by the activity of the thiamin intermediates (8). However, in our experiments the vitamin alone and not the intermediates was effective. It would seem that the treatments used by Leonian did not destroy the vitamin, a substitute for thiamin exists which is more resistant or the intermediates are effective under conditions other than those we have used.

The discovery of organisms which apparently require an external supply of the vitamin itself, suggests the possibility of determining the presence of thiamin and estimating its amount by their use. In fact, it would appear possible to determine the vitamin and one or both intermediates by the use of suitable organisms. In order to use such a method successfully we need to know more of the relation between amount of vitamin supplement and growth of individual fungi, more of the specificity of thiamin and its intermediates and to use suitable means of eliminating the effect of toxic materials which may be present in natural materials. A scheme such as that given below is suggestive only, and even though found eventually to be impracticable from the standpoint of the actual determination, may be useful in showing the known relations of some fungito thiamin and its intermediates.

I Phytophthora cinnamomi

Positive growth effect=thiamin
No growth effect=both intermediates or
pyrimidine alone or

thiazole alone or no thiamin nor intermediates. See II

II Phycomyces Blakesleeanus

Positive growth effect=both intermediates No growth effect=pyrimidine alone or thiazole alone or

no thamin nor intermediates. See III

III Phytophthora fagopyri

Positive growth effect = pyrimidine alone

No growth effect=thiazole alone or no thiamin nor intermediates. See IV

IV Mucor Ramannianus

Positive growth effect = thiazole alone No growth effect=no thiamin nor intermediates.

SUMMARY

1. The following species of Phytophthora apparently required for growth an external supply of thiamin and were unable to use the thiamin intermediates: Phytophthora Boehmeriae, P. cactorum, P. cambivora, P. capsici, P. cinnamomi, P. citrophthora, P. cryptogea, P. Dreschsleri, P. palmivora, and P. parasitica.

2. A medium of mineral salts, asparagine, sugar and thiamin was much more favorable than one lacking asparagine.

3. Phytophthora fagopyri differed from the other species by growing in a medium supplemented with thiamin or its intermediate pyrimidine.

4. A scheme is suggested for determining thiamin or its intermediates by the use of suitable fungi.

THE NEW YORK BOTANICAL GARDEN AND UNIVERSITY OF MISSOURI

Literature cited

- 1. Kögl, Fritz, and Nil Fries. 1937. Über den Einflusz von Biotin, Aneurin und Meso-inosit auf das Wachstum verschiedener Pilzarten. 26 Mitteilung über pflanzliche Wachstumstoffe. Hoppe-Seyler's Ztschr. f. physiol. chem. 249:
- 2. Leonian, Leon H. 1935. The effect of auxins upon Phytophthora cactorum.
- 3. Leonian, Leon H. 1936. Control of sexual reproduction in Phytophthora cactorum. Am. Jour. Bot. 23: 188-190.
- 4. Leonian, Leon H. 1936. Effect of auxins from some green algae upon Phytophthora cactorum. Bot. Gaz. 97: 854-859.
- 5. Leonian, Leon H. 1937. Is heteroauxin a growth-promoting substance? Am.
- 6. Müller, Werner, et William Henri Schopfer. 1937. L'action de l'aneurine et de ses constituants sur Mucor Ramannianus. Möll. Compt. Rend. Acad.
- 7. Robbins, William J., and Frederick Kavanagh. 1937. Intermediates of vitamin B₁ and growth of Phycomyces. Proc. Nat. Acad. Sci. 23: 499-502.
- 8. Robbins, William J. and Frederick Kavanagh. 1938. Vitamin B₁ or its intermediates and growth of certain fungi. Am. Jour. Bot. (in press).
- 9. Robbins, William J. 1938. Organisms requiring vitamin B₁. Proc. Nat. Acad.
- 10. Robbins, William J. and Frederick Kavanagh. 1938. The specificity of pyrmidine for Phycomyces Blakesleeanus. Proc. Nat. Acad. Sci. 24: 141-145.

- 11. Schopfer, W. H. 1934. Versuche über die Wirkung von reinen kristallisierten Vitamin B auf Phycomyces. Ber. d. deut. bot. Gesell. 52: 308-312.
- 12. Schopfer, W. H. et Albert Jung. 1937. L'action des produits de désintégration de l'aneurine sur Phycomyces. Le second facteur de croissance des Mucorinées. Compt. Rend. Acad. Sci. Paris 204: 1500-1502.
- 13. Sinclair, H. M. 1937. Growth factors for Phycomyces. Nature 140: 361.
- 14. Steinberg, R. A. 1936. Relation of accessory growth substances to heavy metals, including molybdenum, in the nutrition of Aspergillus niger. Jour. Agr. Res. 52: 439-448.
- 15. Williams, R. R., and J. K. Cline. 1936. Synthesis of vitamin B₁. Jour. Am. Chem. Soc. 58: 1504-1505.

The winter buds of Brasenia

M. A. Chrysler¹ (with eleven figures)

The water shield, *Brasenia peltata* Gmel. has long attracted attention on account of the extraordinary thickness of the gelatinous layer which invests the upper part of its stem, the petioles and lower surface of the leaf blades. The structure of the glandular hairs which secrete the "mucilage" has been described by Schrenk (1888) and Keller (1893), and the chemical nature of the secretion has also been investigated to a certain extent by the first author. Surmises concerning the function of the secretion have been made by Mrs. Arber (1920) and others. The development of the hairs has been worked out by Schrenk (l.c.).

But we have been unable to find any reference to the peculiar propagules or winter buds. This is the more surprising because of the wide distribution of the plant. They are really conspicuous objects as seen from a boat when one rows through a colony of the water shield during the autumn. Appearing as irregular shaped translucent reddish bodies 30–50 mm. in length, attached to the plant at a distance of a few decimeters below the surface of the pond, they at once attract attention. Perhaps these buds are not produced under all climatic conditions,² but on two occasions, September of 1930 and of 1936, the writer has collected them at the upper end of Lake Maranacook, Kennebec County, Maine. At this location, near the inlet of the lake, the water was from three to four feet deep, and the current was moderate. The occurrence of the plants was somewhat local, being apparently restricted to this part of the lake. A brief account of the morphology of the buds is presented.

The general features are illustrated in the habit photographs. Figure 1 shows a bud still attached to the parent plant, and not quite mature, while figures 2 and 3 show buds after they have become detached. It may be noticed that the lower end of the organ tapers to a blunt point. When the buds are mature the slightest touch dislodges them and they sink to the muddy bottom of the pond, in this respect resembling the winter buds of Potamogeton crispus which was described by Clos in 1856. This habit,

¹ The writer gratefully acknowledges the assistance of Mr. J. M. Seidman in preparation of the material.

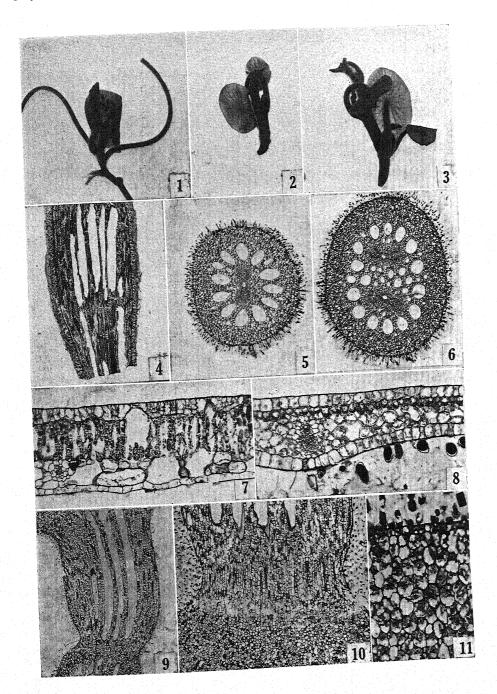
² That these objects are not rare but need merely to be sought at the right time of year is indicated by the discovery of large numbers of them in Cranberry Lake, northern New Jersey, by my colleague, Dr. M. A. Johnson. This collection was made on October 17, 1937, about a month later in the season than the Maine collections, suggesting that the winter buds are formed when the temperature of a pond has fallen.

coupled with the exceedingly slippery nature of the abundant gelatinous covering, makes the collection of the buds an operation subject to many losses. A bud consists of a thickened stem, dwarf leaves with thickened petioles, and the gelatinous layer which envelops the whole organ with the exception of the upper surface of the leaves. Beneath this translucent coating the general color is reddish.

In order to contrast the structure of the winter bud with that of the normal shoot, it may be mentioned that the creeping stem of the latter gives off one or more slender ascending branches with nodes a few centimetres apart, from which spring the long slender petioles bearing floating blades. These are elliptical in shape, about 75×50 mm., and centrally peltate. Toward the end of the summer growth in length of a branch slackens, the internodes becoming successively shorter, but the diameter of the tip region of the stem increases from 2 mm. to as much as 5 mm., having more or less the form of an inverted cone. The visible leaves borne on this region are three or four in number, even five, the basal ones having blades 20-25 mm. long (or even 35 mm.), those near the apex 3-10 mm. long, with a few so small that they cannot conveniently be measured. All leaves of a bud develop very short petioles, hence the whole bud occupies a submerged position. The conduplicate vernation to which Miss Keller (1893) has called attention is quite conspicuous in the younger leaves of a bud. The petioles of these leaves are 2-2.5 mm., in diameter compared with

Explanation of figures

- Fig. 1. Winter bud not quite mature, still attached to branch. Slightly reduced.
- Fig. 2. Winter bud, detached. Slightly reduced.
- Fig. 3. Another winter bud. Axillary buds are present. Slightly reduced.
- Fig. 4. Long. section through base of a winter bud, showing a frequent appearance of the region of abscission. ×10.
- Fig. 5. Trans. section of petiole of a winter bud. The double vascular bundle, cortical canals, storage tissue and abundant secretory hairs are shown. ×16.
- Fig. 6. Trans. section of stem of a winter bud, on same scale as fig. 5. The two pairs of vascular bundles distinguish this organ.
- Fig. 7. Trans. section of normal leaf. The well-developed palisade and large space in the spongy tissue are shown. The section passes through one of the stomata with its large substomatal cavity. $\times 115$.
- Fig. 8. Trans. section of leaf of a winter bud. The poor development of the palisade and intercellular system, also absence of stomata, are indicated. ×115.
 - Fig. 9. Long. section of a winter bud through the region of abscission. ×10.
- Fig. 10. Abscission region of another bud, showing breaking away of the cells. ×23.
- Fig. 11. Portion of epidermis and cortex of stem of a winter bud, showing abundance of starch grains. ×80.



1.7-1.8 mm., for the normal leaves. Two or three of the basal leaves may have a well marked secondary bud in the axil. Most of these features are brought out in figures 1-3.

STRUCTURE OF THE WINTER BUD

Blade. The thickness of the blade of a bud leaf is about 0.17 mm., compared with 0.22 mm. in the floating leaf, that is, about three-fourths as thick. But the structure as brought out by figures 7 and 8 differs in several essential respects. The bud leaf has a more compact mesophyll, lacking extensive intercellular spaces, it entirely lacks the stomata which are characteristic of the upper surface of the floating leaf, and it has only one poorly developed palisade layer in place of the three layers found in the floating leaf. The cells representing the palisade layer are in the bud leaf very short cylinders about $37 \times 24\mu$, i.e., about 3:2, while each of the palisade cells of the floating leaf is about the same length but is only 10μ wide, i.e., nearly 4:1. Thus the tissues do not reach the extreme degree of reduction seen in the submerged leaves of certain species of Potamogeton, e.g., P. pulcher Tuckerm. The absence of stomata in the bud leaves is no doubt associated with the submerged position, while the compact tissues are adapted to storage rather than photosynthesis, for the abundant plastids are loaded with starch. The reddish color already mentioned is due to the presence of anthocyanin in certain of the cells. The secretory hairs occur only on the lower surface, and are exceedingly numerous, producing a layer of gelatin from two to three times as thick as the leaf.

Petiole. This organ is plainly given over to storage, as is shown by the large starch grains which replace chloroplasts. These grains occur in all tissues, although noticeably scarce in the phloem, in which region the grains are small. The proportion of solid tissues to intercellular canals is greater than in the floating leaves, in accordance with specialization for storage. The vascular tissues show the characteristic double phloem and single canal representing xylem. The abundance of secretory hairs may be made out in the photograph (fig. 5.)

Stem. Figure 6, from the same bud as the petiole of figure 5, is photographed at the same magnification. The structure is similar to that of the petiole except that in the stem a pair of the double vascular bundles are present. The large amount of starch stored in the cortical cells is shown in the more highly magnified photograph in figure 11. Again the profusion of secretory hairs is evident. These organs are quite scarce in the mature normal stem.

ABSCISSION

The ease with which the buds may be detached suggests that a mechanism for abscission may be present. Longitudinal sections through the base of a detached bud usually show a clean-cut lower end (fig. 4). looking as though the bud had been cut off by a knife. Sections through buds still attached show a well-marked constriction (fig. 9) at the region of abscission, without necessarily presenting a definite absciss-layer. But in another example, in which the bud was apparently just ready to drop off, zones immediately above and also below nodes were observed in which the cellwalls had changed their composition, as was shown by their taking the safranin stain in place of the fast green typical of the walls of the other internodal cells. Many of these altered cells were breaking down, as is shown in figure 10. Such a zone may be definitely identified as an abscisslayer, comparable to the layer developed by deciduous trees. Longitudinal sections through the base of a bud show the altered condition of cell-walls for some distance back of the break in the case of the phloem cells. These cells moreover are filled with a more or less granular substance which also takes the safranin stain.

TEMPERATURE RELATIONS

Normally, the buds rest during the winter on the muddy bottom of a pond, where the temperature would not fall below 4°C, on account of the slight current which would at any rate be present at the station in which the collections were made. An attempt was made to carry over some of the buds through the winter in the laboratory, by immersing them in a jar of water placed in an electric refrigerator. This material was kept in the refrigerator from September until March. Unfortunately the jar was shifted by an assistant to a position quite near the freezing element, with the result that the jar was found filled with ice. The temperature of the jar was slowly raised, and some days later the buds were transferred to a shallow glass dish and placed in a window. The buds soon softened and decayed. Obviously all that can be inferred is that the buds are killed by temperatures slightly below freezing point.

The result of this experiment corresponds with those of the extended investigation by Glück (1906), who tried the effect of various temperatures on a variety of winter buds, not including *Brasenia*, however.

GERMINATION

The object of our attempt to carry the buds over the winter was primarily to observe the growth from the bud after the resting period. The

only observations at present possible are due to the transfer of part of the material from the cold water of the Maine pond to the warmer water of the New Jersey water supply, which took place upon arrival of the material in the laboratory in September 1936. It was noticed that after lapse of a few days some of the buds showed an elongation of the terminal part of the axis, producing a slim shoot as yet devoid of normal leaves. This observation is definitely in contrast to the mode of "germination" shown in Potamogeton crispus, as reported and figured by Sauvageau (1893); in this plant the new shoots are produced in one or two of the axils of the winter bud. (A further attempt will be made to clear up the "germination" stages.)

NOMENCLATURE

Different terms have been proposed for what we have called "winter buds." "Hibernaculum" is a good but rather clumsy equivalent. The organs evidently belong to the category of "propagules," but this word does not express the whole idea. Mrs. Arber uses the term "turion" when referring to Potamogeton crispus (1920, p. 362). Glüuck (1906) appears to have been the first to use this term in the sense of the winter bud of an aquatic plant—a usage constituting a rather surprising extension of the meaning expressed for example in the definition of turion by Willis (1931): "a scaly sucker or shoot from the ground." At any rate Glück postulates the characters of the turions of water plants (p. 83), and proceeds to distinguish five classes, the distinctions based on whether the modified leaves represent a complete leaf, a petiole, or stipules. It is rather difficult to fit the winter bud of Brasenia into any of Glück's classes, because this bud is really a condensed apical part of a shoot rather than a scaly organ having the essential buds located in the axils of protecting scales. Brasenia on the contrary appears to depend largely on its thick coat of gelatin for what protection its buds need. In fact it is doubtful whether we should apply the term "turion" to the winter bud of this plant. Even then it corresponds to Glück's definition in two respects, viz., separation from the parent plant, and germination apart from the parent.

SUMMARY

In autumn *Brasenia* produces condensed apical organs which are here called "winter buds." With their heavy coating of gelatinous material they are detached from the parent plant by means of an absciss-layer, and fall to the bottom of the pond where they spend the winter. The form and

internal structure of these organs are described. The application of the term "turion" to these winter buds is discussed.

Bureau of Biological Research,
Rutgers University,
New Brunswick, New Jersey

Literature cited

- Arber, Agnes 1920. Water plants, a study of aquatic angiosperms. Cambridge. Clos, D. 1856. Mode de propagation particulier au *Potamogeton crispus*. Bull. Soc. Bot. France 3: 350-352.
- Glück, Hugo 1906. Biologische und morphologische Untersuchungen über Wasserund Sumpfgewächse. Zweiter Theil: Untersuchungen über die mitteleuropäischen *Utricularia*-Arten, über die Turionbildung bei Wasserpflanzen, sowie über *Ceratophyllum*. Jena.
- Keller, Ida A. 1893. The glandular hairs of *Brasenia peltata*. Proc. Acad. Nat. Sci. Phila. 1893: 188-193.
- Sauvageau, C. 1893. Notes biologiques sur les *Potamogeton*. Jour. de Bot. 8: 21-
- Schrenk, Joseph 1888. On the histology of the vegetative organs of *Brasenia peltata* Pursh. Bull. Torrey Club 15: 29-47.
- Willis, J. C. 1931. A dictionary of flowering plants and ferns. Cambridge.



Notes on Myxophyceae, I—IV1

FRANCIS DROUET

In these Notes, herbaria in which specimens are cited are indicated by the following abbreviations: D, my personal herbarium; F, Farlow Herbarium of Harvard University; G, Herbarium of Goucher College; L, Rijksherbarium, Leiden; Mo. Missouri Botanical Garden; N, New York Botanical Garden; S, Naturhistoriska Riksmuseet, Stockholm; T, Herbarium of Wm. Randolph Taylor. This work was done in part at Yale University with the aid of the Theresa Seessel Research Fellowship.

I. NOMENCLATURAL CONSIDERATIONS

Johannesbaptistia pellucida (Dicki) W. R. Taylor & Drouet, comb. nov. Hormospora pellucida Dickie, Journ. Linn. Soc. Bot. 14: 365 (1874). Cyanothrix primaria Gardn., Mem. New York Bot. Gard. 7: 31, pl. 6, f. 57 (1927). C. Willei Gardn., loc. cit., pl. 6, f. 58 (1927). Nodularia? fusca W. R. Taylor, Carnegie Inst. Wash. Papers Tortugas Lab. 25: 48, pl. 1, f. 23 (1928). Johannesbaptistia primaria DeToni f., Noterelle nomencl. algolog. 1:6 (1934); Drouet descr. emend., Univ. So. Calif. Publ. Hancock Pacific Exped. 3: 16, pl. 2, f. 3, 4 (1936). J. Willei De Toni f., loc. cit. (1934). J. Gardneri Frémy, Bull. Soc. Hist. nat. Afr. Nord 26: 95, pl. x (1935).— Specimens examined: BRAZIL: in rock pools, mixed with Cladophora &c., Fernando de Noronha, H. N. Moseley [Challenger Expedition] No. 22 (Type of *Hormospora pellucida* in British Museum). VIRGIN ISLANDS: lagoon, Charlotte Amalie, W. A. Hoffman 146593, Sept. 1937 (D, T). PUERTO RICO: San Juan, Lake Tortuguero, N. Wille 830b (Type of Cyanothrix primaria), 830e (Type of C. Willei), 844e, 849c, 5 Feb. 1915 (all in Herb. New York Bot. Gard.). FLORIDA: Dry Tortugas, among other filamentous algae, W. R. Taylor, July 1925 (Type of Nodularia? fusca in Herb. W. R. Taylor) ECUADOR: Galapagos Islands, Isabela Island, W. R. Taylor 123, 12 Jan. 1935 (D); Fernandina Island, Taylor 155, 14 Jan. 1935 (D). CALIFORNIA: in brackish water west of Newport Beach, G. J. Hollenberg 1533e, 26 Sept. 1934 (D, Hollenberg).

During a visit in London in 1937, Prof. Wm. R. Taylor discovered the original material of *Hormospora pellucida*, recognized its similarity to his own *Nodularia? fusca*, and at once communicated his notes to me. More recently, through the great kindness of Messrs. G. Tandy and J. Ramsbottom of the British Museum (Natural History), I was permitted to

¹ Contribution from the Osborn Botanical Laboratory of Yale University and from the Department of Botany, Marine Biological Laboratory.

to examine a portion of this same material. The filaments are excellently preserved and match in every respect those of the types of Cyanothrix primaria and C. Willei. Prof. G. J. Hollenberg has obligingly sent me material of his collection from California cited above. Frémy (loc. cit.) and Seurat & Frémy, idem 28: 294 (1937), have reported specimens answering to the description of this species from Tunisia, Algeria, and the Dutch West Indies under the superfluous name (cf. Art. 50 of the present International Rules) J. Gardneri. In view of its very wide distribution in saline waters of tropical and subtropical regions of the earth, we should not be surprised to discover that this species had been recognized and described at a date far earlier than 1927, when C. primaria Gardn. was published.

Schizothrix Mexicana Gom., Ann. Sci. nat. VII Bot 15: 304 (1892). Lyngbyopsis Willei Gardn., Mem. New York Bot. Gard, 7: 55, pl. 11, f. 1 (1927).—Specimens seen: PUERTO RICO: on rocks in a brook 5 km. north of Utuado, N. Wille 1597, 8 Mar. 1915 (Type of Lyngbyopsis Willei in Herb. New York Bot. Gard.). JAMAICA: on rock in 'Wag Water,' Castleton, J. E. Humphrey, 12 Apr. 1893 (F, G).

The type of L. Willei represents truly a species of Schizothrix and answers in every respect to Gomont's description of S. mexicana. The sheaths are thin and very hyaline, but their nature is easily demonstrated when colored blue by treating with chlor-zinc-iodine² or when stained lightly with dilute solutions of various dyes. Even after long and meticulous searching in the type material, I am unable to discover the interwoven branching of filaments described as peculiar to the monotypic genus Lyngbyopsis Gardn. (ibid. 54). Hormogonial masses are present, and it is possible that the branching of filaments in such masses was studied in an unstained condition. Unfortunately I have not had the opportunity to examine authentic material of S. mexicana annotated by Gomont; but there can be little doubt, judging from Gomont's description, that the two types are similar. The Jamaican collection cited above is the one reported by Collins in Proc. Amer. Acad. 37: 240 (1901).

PHORMIDIUM PENICILLATUM³ Gomont in Jadin, Bull, Soc. Bot. France 40: clix (1893). Symploca profunda W. R. Taylor, Carnegie Inst. Wash. Papers Tortugas Lab. 25:47, pl. 1, f. 18 (1928). Oscillatoria maricola Gardn., New York Acad. Sci. Sci. Surv. Porto Rico 8: 270, pl. 1, f. 3 (1932).—Specimens examined: FLORIDA: dredged, White Shoal Sta. 3, Dry Tortugas, W. R. Taylor 254, 11 July 1924 (Type of Symploca profunda in

² For the method of employing this reagent in Myxophycean studies, see Drouet, Amer. Journ. Bot. 24: 604, footnote 7 (1937).

³ The original spelling is 'penicellatum.'

Herb. W. R. Taylor); dredged, Loggerhead Key, Dry Tortugas, Taylor 284, 12 July 1924 (T); dredged beyond Southwest Channel in 20 fathoms, Dry Tortugas, Taylor 723, 11 June 1925 (T). PUERTO RICO: Culebra Island, M. A. Howe 4366, 7 Mar. 1906 (N); Muertos Island (Caja de Muertos), Howe 7479, 8 July 1915 (Type of Oscillatoria maricola in Herb. New York Bot. Gard.); east of mouth of Guanica Harbor, Howe 7311, 1 July 1915 (N); dredged, mouth of Guanica Harbor, Howe 7446, 4 July 1915 (N). JAMAICA: 'Blue Hole,' shaded shallow water, A. E. Wight, 26 May 1906 (det. Gomont: D, F, S).

The two species proposed here as synonyms of P. penicillatum are based upon morphologically similar types, and I am unable to find characters to separate these types from the Jamaican specimens annotated by Gomont as P. penicillatum. All the specimens cited above consist of penicillate plant masses from salt water, principally below low tide level; the cells have rose- or violet-colored protoplasm and are usually longer than broad; the calyptra of the apical cell is rather inconspicuous and rotund or depressed-conical. Gomont's type from Réunion was described as having trichomes 6μ in diameter; the Antillean material seen here has trichomes ranging from 5.5μ to 9μ in diameter.

II. MYXOPHYCEAE FROM COSTA RICA

A small package of blue-green algae from Costa Rica was recently sent to me for study by Dr. Carroll W. Dodge of the Missouri Botanical Garden. I interpret the specimens as follows, listing them under specific names according to provinces:

CALOTHRIX CONTARENII (Zanard.) Born. & Flah., Ann. Sci. nat. VII Bot. 3: 355 (1886).—One collection on wood in salt water, PUNTA-RENAS: along seashore between Río Sándoval and Río Tigre, *Dodge 4357*, 1 May 1930 (D, Mo).

CALOTHRIX PILOSA Harv. ex Born. & Flah., ibid. 363 (1886). Tildenia pilosa Polj., Bull. Jard. Bot. Princip. U.S.S.R. 27: 227 (1928). Setchelliella pilosa DeToni f., Noterelle nomencl. algolog. VIII (1936).—On wood in salt water, PUNTARENAS: along seashore between Río Sándoval and Río Tigre, Dodge 4537A, 1 May 1930 (D, Mo).

FREMYELLA VITIENSIS (Born. & Flah.) DeToni f., loc. cit. (1936). *Microchaete vitiensis* Ask. ex Born. & Flah., ibid. 5: 84 (1887).—Marine, PUNTARENAS: along seashore between Río Sándoval and Río Tigre, *Dodge*, 1 May 1930 (D, Mo).

Scytonema Hofmannii Ag. ex Born. & Flah., ibid. 97 (1887).—On tree trunks, often somewhat lichenized. ALAJUELA: la Palma de San Ramón, A. M. Brenes 176, 177, 12 Nov. 1920 (D, Mo). LIMON: on

Croton at house, Hamburg Farm, Dodge & F. Nevermann 7454, 31 Mar. 1930 (Mo).

SCHIZOTHRIX THELEPHOROIDES (Mont.) Gom., idem 15: 319, pl. x, f. 1-4 (1892).—On soil and mixed with other algae, mosses, and lichens, ALAJUELA: Alto del Mendongo del San Ramón, A. M. Brenes 285, 9 Jan. 1930 (D, Mo).

OSCILLATORIA ANIMALIS Ag. ex Gom., ibid. 16: 227, pl. vii, f. 11 (1892).

—On wet mosses with juvenile *Nostoc* sp., SAN JOSE: potreros of Rancho Redondo, *Dodge & W. S. Thomas 5267*, 18 Nov. 1929 (D, Mo).

III. MYXOPHYCEAE FROM ARGENTINA

During the period November 1936 until January 1937, Dr. Stillman Wright was engaged in a limnological survey of some freshwater lakes of central Argentina, under the joint auspices of the División de Piscicultura of Argentina and the Commissão Technica de Piscicultura of Brazil. His formalin-preserved material, sent to me for study and distribution, consists of the following specimens, cited geographically under the specific names according to provinces. Serial numbers of collections in italics are to be understood as those of Dr. Wright.

MICROCYSTIS AERUGINOSA KÜTZ., Tab. phyc. 1: 6, Tab. 8 (1845–49).— Abundant in the plankton of many lakes, BUENOS AIRES: Laguna Los Chilenos near Dufaur, 2113, 11 Jan. (D); Laguna Blanca Grande, 2098, 14 Jan. (D, F, L, N, S); Laguna Chascomus, 2101, 11 Nov. (D). SAN LUIS: with Phormidium mucicola, Laguna Tala, 2111, 10 Dec. (D, F, L, S); with P. mucicola, Laguna Garcia, 2096, 7 Dec. (D, L, N, S); with P. mucicola, Primera Laguna, 2059, 4 Dec. (D).

CALOTHRIX PARIETINA (Näg.) Thur. ex Born. & Flah., Ann. Sci. nat. VII Bot. 3: 366 (1886).—In an incrustation on a fish tank, BUENOS AIRES: Chascomus, 2102, 19 Nov. (D, F, L, N, S).

GLOEOTRICHIA NATANS (Hedw.) Rabenh. ex Born. & Flah., ibid. 4: 369 (1886).—One collection, SAN LUIS: Laguna Viejo, 2094, 8 Dec. (D, F, L, N, S).

ANABAENA ?FLOS-AQUAE (Lyngb.) Bréb. ex Born. & Flah., ibid. 7: 228 (1888).—The material is without spores, and I therefore assign the specific name with some uncertainty. Forming a considerable part of the plankton from one lake, SAN LUIS: Tres Lagunas (No. 3), 2110, 6 Dec. (D, F, L, N, S).

APHANIZOMENON FLOS-AQUAE (L.) Ralfs ex Born. & Flah., ibid. 241 (1888).—From the plankton, BUENOS AIRES: Laguna Carlito, Necochea, 2093, 17 Jan. (D, F, L, N, S).

PLECTONEMA NOSTOCORUM Born. ex Gom., idem 16: 102, pl. i, f. 11 (1892).—With *Calothrix parietina* in an incrustation on a fish tank, BUENOS AIRES: Chascomus, 2102, 19 Nov. (D, F, L, N, S).

PHORMIDIUM MUCICOLA Naum. & Huber in Huber-Pestalozzi & Naumann, Ber. d. d. bot. Ges. 47: 68, f. 1-6 (1929).—I discuss the occurrence of this species in North America in a current number of Rhodora (1938). In the Argentine lakes it is abundant within the sheaths of *Microcystis aeruginosa*, but wholly absent in collections from some of the lakes. BUENOS AIRES: Laguna Los Chilenos near Dufaur, 2113, 11 Jan. (D). SAN LUIS: Laguna La China, 2112, 4 Dec. (D, L, N, S); Laguna Tala, 2111, 10 Dec. (D, F, L, S); Laguna Garcia, 2096, 7 Dec. (D, L, N, S).

OSCILLATORIA PRINCEPS Vauch. ex Gom., ibid. 206, pl. vi, f. 9 (1892). Lyngbya gigantea Lewis, Zirkle & Patrick, Journ. Elisha Mitchell Sci. Soc. 1933: 221 (1933).—Two collections, CÓRDOBA: creek near city of Córdoba, 2116, 21 Dec. (D, F, L, N, S); Laguna Embolse Rio III, Almafuerte, 2115, 18 Dec. (D, L, N, S).

OSCILLATORIA ANGUINA Bory ex Gom., ibid. 214, pl. vi, f. 16 (1892). *Phormidium Chungii* Gardn.,⁴ Univ. Calif. Publ. Bot. **14:** 4, pl. 1, f. 5 (1927).—One collection: CÓRDOBA: Laguna Embolse Rio III, Almafuerte, 2091, 16 Dec. (D, F, L, N, S).

OSCILLATORIA OKENI Ag. ex Gom., ibid. 232, pl. vii, f. 18 (1892).—Specimens seen: BUENOS AIRES: Australian tank, Estancia "La Lola," Dufaur, 2092, 13 Jan. (D, F, L, N, S). SAN LUIS: Laguna El Sarco, 2106, 7 Dec. (D). CÓRDOBA: with O. anguina, Laguna Embolse Rio III, Almafuerte, 2091, 16 Dec. (D, F, L, N, S).

OSCILLATORIA CHALYBEA Mert. ex Gom., ibid. 232, pl. vii, f. 19 (1892); Borge, Ark. f. Bot. 6(4): 11 (1906).—Specimens seen from Argentina: JUJUY: with *Phormidium laminosum*, Quinta, in aqua 36.5° [C], R. E. Fries (Regnell Expedition) No. 9, 12 June 1901 (S). CÓRDOBA: with O. anguina, Laguna Embolse Rio III, Almafuerte, 2091, 16 Dec. (D, F, L, N, S).

OSCILLATORIA SPLENDIDA Grev. ex Gom., ibid. 224, pl. vii, f. 7-8 (1892). —BUENOS AIRES: with O. Okeni, Australian tank, Estancia "La Lola," Dufaur, 2092, 13 Jan. (D, F, L, N, S).

SPIRULINA PLATENSIS (Gom.) Geitl., Rabenh. Kryptogamen-Fl. 14:

⁴ The trichomes of the Type of *P. Chungii* in the Farlow Herbarium (CHINA: Fulung Hot Springs, Tanggate, Foochow, *Chung A452*) are indistinguishable from those of other specimens placed under the name *O. anguina* in my herbarium. The trichomes are mixed with filaments of other sheathed Myxophyceae, but I am unable to demonstrate sheath material (except in hormogonial masses) belonging properly to *P. Chungii*.

925, f. 589, 590 (1932). Arthrospira platensis (Nordst.) Gom., ibid. 247, pl. vii, f. 27 (1892). S. Jenneri var. platensis Nordst. ex Gom., loc. cit. (1892); Nordst. in Wittr. & Nordst., Alg. exs. 14: 679 (1884), in Farlow Herb.—The original material of this species was collected in Uruguay by Arechavaleta and distributed in the exsiccata noted above. Several workers have since reported collections from Africa. Miss Rich in Rév. algol. 6(1): 75-79 (1931) has given us detailed observations upon her material from Kenya Colony. She reports that in a considerable number of individuals the trichomatal dimensions vary within a much wider range than that noted in Gomont's description. Gomont, of course, based his diagnosis upon a single dried collection from another continent. As did the African collections, the material cited here comes from highly alkaline lakes: SAN LUIS: with Anabaena ?flos-aquae, Tres Lagunas (No. 3), 2110, 6 Dec. (D, F, L, N, S); Laguna El Chorriado, 2089, 10 Dec. (D, F, L, N, S).

Spirulina major Kütz. ex Gom., ibid. 251, pl. vii, f. 29 (1892). S. densa Lillick, Amer. Midl. Nat. 16: 210, f. 1A (1935).—Two collections: BUENOS AIRES: with Oscillatoria Okeni, Australian tank, Estancia "La Lola," Dufaur, 2092, 13 Jan. (D, F, L, N, S). SAN LUIS: Laguna El

Sarco, 2106, 7 Dec. (D).

IV. NORTH AMERICAN MYXOPHYCEAE IN THE SCHWEINITZ HERBARIUM

During a recent visit at the Academy of Natural Sciences in Philadelphia, Dr. F. W. Pennell and Dr. Ruth Patrick invited me to look through the rather large algal collections of Dr. Lewis David von Schweinitz (1780-1834). The Myxophyceae, although few in number, are chiefly freshwater forms collected in the vicinity of Winston-Salem, North Carolina, presumably between the years 1812 and 1821; some specimens come from other states. Few data appear upon the specimens themselves; beyond a generic or specific name, there is usually only a terse note "Salem" for what is now Winston-Salem, "Virg" for Virginia, "Beth" for Bethlehem, Pennsylvania, etc. Drs. Pennell, Schallert, Benedict, and Barnhart have given us an enlightening symposium on the life and collections of Dr. Schweinitz in Bartonia 16: 1-36 (1934). In his unpublished manuscript, "Flora Salemitana" (dated 1821), now on file in the Herbarium of the Academy, Schweinitz has mentioned most of the North Carolina specimens by name and has given a few notes on the locality and habitat of each. In preparing the labels and in citing in the enumeration below, I have included all such information from the above sources as could with some degree of certainty be attached to the specimens individually. In the collection also are specimens of no inconsiderable his-

⁵ See Pennell in Bartonia 13: 50-52 (1931).

torical interest communicated to Schweinitz by his friend and correspondent, Dr. John Torrey. These are indicated most often by the simple annotation "Torrey," sometimes with a transmittal number, sometimes with more exact data. In the list below, all specimens cited are to be found in the Herbarium of the Academy at Philadelphia and, unless otherwise indicated, are to be understood as collected by Schweinitz himself.

NOSTOC COMMUNE Vauch. ex Born. & Flah., Ann. Sci. nat. VII Bot. 7: 203 (1888).—NORTH CAROLINA: as N. commune, common at certain seasons upon the earth, Winston-Salem.

NOSTOC PRUNIFORME (L.) Ag. ex Born. & Flah., ibid. 215 (1888).—PENNSYLVANIA: as "N. crepitans Nobis," Bethlehem.

NOSTOC VERRUCOSUM (L.) Vauch. ex Born. & Flah., ibid. 216 (1888).—VIRGINIA: as N. Botrydium.

Scytonema Guyanense (Mont.) Born. & Flah., ibid. **5:** 94 (1887).— UNITED STATES: as *S. atrovirens*, on rocks, *comm. Torrey*. NORTH CAROLINA: as *Conferva ebena*, Winston-Salem.

PORPHYROSIPHON NOTARISII (Menegh.) Kütz. ex Gom., idem 15: 331, pl. xii, f. 1, 2 (1892).—For a discussion of the morphology and recent synonymy of this species, see Drouet in Amer. Journ. Bot. 24: 601 (1937). NORTH CAROLINA: as *Conferva ericetorum*, on the earth, red, Winston-Salem.

Lyngbya confervoides Ag. ex Gom., ibid. 16: 136, pl. iii, f. 5, 6 (1892).—UNITED STATES: as Bangia atropurpurea, sea shore, comm. Torrey 189.

LYNGBYA OCHRACEA (Kütz.) Thur. ex Gom., ibid. 149 (1892).—NORTH CAROLINA: in most metallic springs—this from near Pilot [Mountain], near Winston-Salem.

PHORMIDIUM TRELEASEI Gom., Bull. Soc. Bot. France 46: 37 (1899).

—The one collection⁷ comes from the type locality of the species, AR-KANSAS: as Oscillatoria calida, hot springs of the Washita [now Hot Springs, near the Ouachita River], 150° F, comm. Torrey.

PHORMIDIUM INUNDATUM Kütz. ex Gom., Ann. Sci. nat. VII Bot. 16: 172, pl. iv, f. 31, 32 (1892). P. purpurascens var. elegans Drouet, 8 Bot. Gaz.

⁶ The correspondence of Schweinitz and Torrey has been published in fairly complete form in Mem. Torr. Bot. Club 16(3) (1921). Unfortunately, lists of collections exchanged between the two men have been omitted; and I have not had the opportunity to hunt for further data on the Torrey specimens among the letters themselves.

⁷ It is not clear whether Thomas Nuttall, Thomas Drummond, or Zina Pitcher collected this material. See Mem. Torr. Bot. Club 16: 137, 151, 248, 277, 279 (1921).

⁸ The Type of *P. purpurascens* var. *elegans* in my personal herbarium (MISSOURI: in a spring at east side of Highway 28 at Gasconade River Bridge, Pulaski

95: 696, f. 3 (1934).—NORTH CAROLINA: as Oscillatoria fontinalis, rare in springs on stones, Winston-Salem.

PHORMIDIUM RETZII (Ag.) Gom., ibid. 176, pl. v, f. 6–9 (1892).—NORTH CAROLINA: as *Conferva*, Winston-Salem.

PHORMIDIUM SETCHELLIANUM Gom., ibid. 190, pl. v, f. 25, 26 (1892). —It is unfortunate that we have no further data on this collection, for the species is known to me only in specimens from New England. UNITED STATES: as Oscillatoria Friesii, comm. Torrey 353.

PHORMIDIUM FAVOSUM (Bory) Gom., ibid. 180, pl. v, f. 14, 15 (1892).— UNITED STATES: as Oscillatoria fusco-purpurea, comm. Torrey 161. NORTH CAROLINA: as O. fontinalis, rare in springs on stones, Winston-Salem

PHORMIDIUM UNCINATUM (Ag.) Gom., ibid. 184, pl. v, f. 21, 22 (1892).
—NORTH CAROLINA: as Oscillatoria flexuosa?, Winston-Salem.

PHORMIDIUM AUTUMNALE (Ag.) Gom., ibid. 187, pl. v, f. 23, 24 (1892). Lyngbya hahatonkensis Drouet, Bot. Gaz. 95: 698, f. 5 (1934).—NORTH CAROLINA: as Oscillatoria vaginata, on the staircase of Barhouse, Winston-Salem.

OSCILLATORIA LIMOSA Ag. ex Gom., ibid. 210, pl. vi, f. 13 (1892).— NORTH CAROLINA: as O. flexuosa?, Winston-Salem; as Conferva canalicularis, a handsome one in Stotz bottom garden, Winston-Salem.

OSBORN BOTANICAL LABORATORY OF YALE UNIVERSITY AND DEPARTMENT OF BOTANY, MARINE BIOLOGICAL LABORATORY

County, Drouet 1033, 1 Oct. 1932) differs in no respect from the specimen of P. inundatum examined by M. Gomont in the Farlow Herbarium, MAINE: on water trough, Eastport, W. G. Farlow, Sept. 1877. The violet-black color of the plant mass as described in the original publication of the var. elegans is evident only when the mass is observed beneath the surface of the water: out of the water, the color is quite bluegreen.

Notes on Maryland algae¹

HAROLD C. BOLD (WITH PLATES 6 AND 7)

From 1934 through 1937 the author was resident for six weeks each summer at the Chesapeake Biological Laboratory which is located on Solomons Island, Calvert County, Maryland. The following paper contains notes on a study of the algae of that region and descriptions of new species, of forms new to the United States or significant for some other reason. The organisms discussed below are all fresh-water forms and are treated according to the classification given by Smith (1933); all belong to the order Volvocales.

POLYBLEPHARIDACEAE

PYRAMIMONAS MONTANA Geitler (figs. 1-12).—Although eight species of this genus have been described from abroad (Pascher, 1927), but two have been recorded as present in the algal flora of this country. Smith (1933) reports finding P. tetrarhyncus Schmarda from Wisconsin lakes and earlier Prescott (1926) reported P. inconstans Hodgetts from Iowa. During the past four summers small puddles in the clay mud of a barnyard at Solomons became colored a brilliant green due to the presence of such organisms as Pandorina morum Bory, Eudorina elegans Ehr., Chlamydobotrys stellata Korsch.; during periods of intense sunlight a bright green cloud of organisms gathered near the surface of the most intensely illuminated portion of each pool and microscopic examination revealed that these streaks consisted practically entirely of Pyramimonas sp. Attempts to cultivate the organism have been unsuccessful; preparation of stained slides has been only partially successful and efforts to preserve the organism have failed because of the absence of a cell wall. The pools containing the organism are supplied with water from an artesian well which runs into a trough and overflows on the surrounding clay. At times pools become completely dry but following rains they again become populated with Pyramimonas and the associated organisms.

Figures 1-12 illustrate the organism, which seems to be identical with *P. montana* Geitler (Geitler, 1925). The cells are bluntly conical and swim with the base of the cone directed forward. Most of the individuals are slightly four lobed or ridged at the anterior end (figs. 1, 2) but there are all gradations from this condition to cells with almost truncate anterior poles (fig. 12). In ridged individuals there is a depression in the center of the anterior end among the ridges in which the flagella are inserted. The

¹ Contribution Number Sixteen from the Chesapeake Biological laboratory.

cells are rounded in end view and optical transverse section and taper symmetrically toward the posterior. Cell size in my specimens varies from 12 to 20 microns in length and from 8 to 16 microns in width at the broadest point; Geitler's specimens varied from 17 to 22.5 microns. The cells move very rapidly forward turning on their long axes and when they strike another object they rapidly reverse the direction of their movement without reversing the orientation of their bodies. Four flagella are attached to the central region of the anterior end of the cell and are about as long as the length of the cell body. Treatment with weak iodine solution or osmic acid vapor reveals the presence of a small but distinct blepharoplast to which the flagella are attached in such a way that they appear to diverge at approximately 90° angles when the cell is at rest (figs. 3, 8–10). A cell wall is lacking and the cells are therefore somewhat metabolic as indicated by changes in shape when two individuals collide.

On either side of the blepharoplast a contractile vacuole is visible in the living cells (figs. 1, 2, 3 etc.); these contract and expand alternately. The chloroplastid is cup shaped and massive and appears to fill the cell in surface view. In longitudinal optical section it becomes apparent that there is a shallow region of colorless cytoplasm at the posterior pole of the cell in which the nucleus is visible (figs. 2, 5, 7). The chloroplastid in living cells is highly granular and contains scattered starch grains and oil droplets. When the cell is ridged the chlorophyll-bearing cytoplasm extends out into the ridges anteriorly. Deep within the chloroplastid in the basal region of the cell a single pyrenoid is usually embedded; it is rarely entire (figs. 1, 2), usually consisting of a number of fragments or portions (figs. 5, 8, 11). The pyrenoid is usually surrounded by a ring of small starch grains (figs. 1, 2); figure 5a represents a compound pyrenoid as it appears in a cell stained with iodine; each portion consists of a proteinaceous portion, at the periphery of which occurs a violet-stained starch grain. Other starch grains which presumably originate around the pyrenoid, occur in other regions of the chloroplastid.

The nucleus lies in the region of colorless cytoplasm within the chloroplastid and is distinctly pear-shaped (figs. 8, 11); the beak of the nucleus extends between the two contractile vacuoles and lies beneath the blepharoplast. In my specimens the nucleus was not visible in the living cells but became sharply defined when the cells were moribund or when treated with osmic acid, iodine or with haematoxylin after fixation. Each nucleus contains a single large spherical nucleolus and in stained preparations there is some evidence of the presence of a chromatin network.

Hanging drop mounts did not remain in good condition for more than forty-eight hours, probably due to lack of oxygen and to the multiplication

of numerous bacteria. In such cultures some individuals disintegrated, while others rounded up, became enveloped in a thick gelatinous wall, and apparently entered into a period of dormancy (fig. 4).

Multiplication consists of the longitudinal division of one cell into two; dividing individuals were encountered most frequently in collections made late in the afternoon. No details of nuclear division were obtained in fixed preparations; Geitler (1925) figures one stage which indicates that it is mitotic. Aside from actual cleavage there are two criteria which indicate impending cell division. The pyrenoid, whether simple or fragmented, becomes elongated in a plane at right angles to the long axis of the cells (fig. 6). As the time for cytokinesis approaches the elongated mass is gradually separated into two portions (figs. 7, 8) which form the pyrenoids of the daughter cells (figs. 10, 11). A second indication of approaching division is the gradual increase in the number of flagella. The cell figured as 5 had six flagella two of which were shorter and were apparently growing out from the blepharoplast in anticipation of cleavage. Many individuals with eight flagella were seen (figs. 7, 8) in collections examined late in the afternoon and evening, but by the following morning all cells in the culture were again quadriflagellate indicating that cell division had been completed. The cells apparently begin to increase the number of flagella long before cytokinesis is completed or even initiated. In division, as observed in living cells, the flagella begin to diverge into two groups of four as the anterior pole of the cell broadens (figs. 7, 8) and since the contractile vacuoles also diverge growth probably occurs most actively in the region just between them. Each daughter cell therefore receives one contractile vacuole from the mother cell. The posterior portion of the cell subsequently increases in size and a cleavage furrow appears in it (fig. 8). Similarly a furrow is initiated between the groups of diverging flagella and when the furrows meet, cell division is complete. Cells which are still incompletely segregated already contain two contractile vacuoles each (fig. 9), so that one must arise de novo very quickly in each. Figure 10 illustrates one product of a recent cell division fixed with osmic vapor. As in other species of the genus, cell division occurs while the organism is motile. The organism described above appears to be very close to Geitler's (1925) Pyramimonas montana which he found in an Alpine pool at an altitude of five thousand feet. In P. montana Geitler reports that the ratio of length to breadth is that of 2:1 or slightly less than 1; in the Maryland organism it is approximately 8:5, but occasional relatively longer individuals occur. Geitler states that his species was pale yellowish in color while the organisms I observed were a deep grass-green. It is well known however that differences in mineral content of the medium profoundly

affect the intensity of the pigmentation. The Maryland organisms therefore should probably be considered as a form of P. montana Geitler; it is here reported for the first time from the United States.

CHLAMYDOMONADACEAE

CARTERIA CRUCIFERA Korsch. (figs. 16-17).—This organism occurred in considerable abundance during the summer of 1935 in a small lily pool in the garden of a residence at Solomons Island. It has not been seen in succeeding summers but as the drawings indicate it is undoubtedly identical with C. crucifera Korsch.2 The cells among my specimens vary from a minimum of 10μ to a maximum of 20 in length; Korschikoff reports individuals up to 27μ in length. The outstanding character of the species is the cruciform arrangement of the flagella which originate from the prominently four-parted papilla. The pyrenoid lies on the median longitudinal axis of the cell, deep within the chloroplastid. The latter is cupshaped, sometimes open also posteriorly and is characteristically striated or ribbed longitudinally. The cells divide while quiescent into groups of four or eight (fig. 17) and these daughter cells when liberated soon achieve the size of the parent cells. The chloroplastid in my specimens was filled with abundant starch grains. The nucleus is located in the posterior third of the cell and lies within the opening of the chloroplastid. The shape of the chloroplastid and the central position of the pyrenoid indicate that the species belongs in the section Pseudoagloë Pascher. As far as I can ascertain this organism is reported here for the first time from the United States.

Carteria ellipsoidalis sp. nov.—Cellulis vere et semper ellipsoidalibus; chromatophora aperte urceolata; stigmate in media parte vel subanteriore chromatophorae; pyrenoide singula grande axiale; nucleo incluso in cytoplasmate sine colore; cellulis sine papilla; vacuolibus contractalibus praesentibus; longitudine cellulae vegetativae $6-24\mu$; ceteris characteribus similibus generi. Propagatio fit 2, 4 aut 8 cellulis intra cellulae matricalis mebranum ortis. Hab. In fossa juxta agrum campestrem, Solomons, Calvert Co., Maryland (figs. 18–20).

These organisms were repeatedly collected from barnyard puddles similar to those in which *Pyramimonas montana* occurred. The cells vary from 10 to 25 microns in length and are always truly ellipsoidal in shape. The chloroplastid is very clearly urn- or cup-shaped with the opening usually extending well back toward the posterior half of the cell. There is

² Apparently the original publication of this species is in Pascher (1927, p. 157), since it is not found in any of Korschikoff's papers that are available: the case is an example of Pascher's inconvenient habit of failing to indicate species which are described as new.

a single axial pyrenoid which lies near the base of the chloroplastid, the latter being filled with minute starch grains some of which surround the pyrenoid. The stigma is small and located within the anterior third of the chloroplastid. The four flagella are about equal in length to the cell body and are attached to a minute blepharoplast which lies very near the margin of the protoplast. The cell wall is thin and lacks a papilla, and the protoplast is slightly truncated in this region. Cell division is longitudinal and occurs while the cells are in a quiescent condition; four- and eight-celled stages are commonly found (fig. 20). This organism is closely related to C. globosa Korsch. from which it differs plainly, however, in its pronounced and constant ellipsoidal form and in the smaller size of its cells. The present species like C. globosa belongs to the section Eucarteria.

Chlamydomonas metastigma (Stein) Gorosch. (fig. 21).—This organism occurred sparingly in barnyard puddles along with the above species of Carteria. It belongs to the sub-genus Amphichloris Pascher, and is characterized by the presence of both anterior and posterior pyrenoids which are embedded axially in the urn-shaped chloroplastid. The latter is partially perforated near the equator of the ellipsoidal cell and the stigma is posterior to this opening. The nucleus lies in the central portion of the cell and is often visible through the opening in the chloroplastid. The latter is like a window and does not completely divide the chloroplastid. In my specimens vegetative cells vary in length from 11.8 to 16 microns the cells being slightly smaller than those observed by Goroschankin (1891). The cells lack a papilla; no stages in reproduction were observed.

Chlamydomonas schizochlora sp. nov. (figs. 13–15).—Cellulis vegetativis grandibus, 30– 40μ longitudine, cylindroidibus; anteriore papilla obtusa; chromatophora fissa in multas partes sed in toto urceolata; una pyrenoide in quoque segmente; stigmate lanceolato usque ad 5μ flagellis brevibus, minoribus quam dimidio longitudinis cellulae; nucleo subanteriore, sphaerico; vacuolibus contractalibus praesentibus. Propagatio non observata est. Hab.: In stagno, Solomons, Calvert Co., Md.

This organism was observed infrequently sparingly mixed with other algae in a small pond or swamp at Point Patience, Calvert County, Md., and is clearly a member of the sub-genus *Pleiochloris* Pascher in which the cells contain many laterally distributed pyrenoids. The cells are elongated, cylindrical-ellipsoidal and relatively large varying from 31–40 microns in length and are somewhat less than half as wide. The posterior and anterior poles are equally rounded. The chloroplastid as a whole is cup- or urnshape, but is incompletely divided into mosaic-like segments each of which contains a single pyrenoid superficially embedded. The number of chloroplastid segments fluctuate in my specimens between eleven and seventeen.

The stigma is anterior, in edge view pointed at both ends, in face view narrowly elliptical, and may reach a length of 5 microns. Two contractile vacuoles are present beneath the lenticular papilla and below them in the colorless cytoplasm a rather large nucleus is present (figs. 13–15). The two flagella are short, less than one half the length of the cell body and they emerge close together through the broad papilla. The cells I observed were extremely sluggish in their movements, perhaps because of the large size of the cells in relation to the size of the flagella. This organism is closely related to *C. breviciliata* Korsch. from which it is readily distinguishable however by the mosaic chloroplastid and by the anterior position of the extremely elongated stigma and by the more anterior position of the nucleus.

PHACOTACEAE

Dysmorphococcus variabilis Takeda (figs. 22-25).—This organism appeared in great numbers in barnyard puddles along with other Volvocales during the summer of 1936. The genus was described by Takeda (1916) from material collected in a small pool in Surrey, England; Korschikoff (1925) reports the occurrence of D. variabilis Takeda and a new species D. coccifera in the vicinity of Charkow. As is typical of members of this family, the cells of Dysmorphococcus are encased within a lorica which is almost colorless in young individuals but becomes dark brown in more mature cells. The surface of the lorica appears rough under low magnifications but higher magnification reveals the presence of a pattern or sculpturing on the lorica. Takeda reported that this consisted of closely placed granules: "It can be positively stated," he says, "that they are granules, and not scrobiculations." Korschikoff on the contrary reports that the shell in the same species is ornamented not with granules but with true pores which in transverse section, as seen at the surface, appear to be hexagonal. I can substantiate the observations of Korschikoff on this point though there seems to be a high frequency of occurrence of pentagons and other types of polygons in cross sectional views of the pores. An accurate picture of the pores is only obtained through the use of an apochromatic optical system. Under lower magnifications the shell does not appear granulated and I have represented it in this manner in figure 25, below which I have depicted a more detailed segment of a shell. Takeda mentions the occurrence of a "dotted line" running longitudinally around the shell; critical observation convinces me that this is always present and that it consists in reality of a narrow band of wall material in which no pores occur (fig. 23) and along which the splitting of the shell occurs at the time of reproduction. Korschikoff (1925) comes to a similar conclusion in

his studies of D. coccifera. The size of the shells which I have observed falls within the specific limits given by Takeda, namely 14-19 microns long and between 13 and 17 microns broad across the flattened surface. The lorica displays a pronounced dorsiventrality, being somewhat flattened in a plane at right angles to the long axis especially posteriorly (fig. 23); it is more rounded usually anteriorly (fig. 24). The flagella of the contained protoplast emerge through two minute openings which are oriented at about 45° angles with reference to a plane parallel to the broad surface of the shell. The protoplast is always smaller than the lorica and is pear-shaped with the colorless beak being attached near the apex of the shell. Along with Takeda and Korschikoff I have been unable to convince myself that the protoplast is walled. Its structure is typically Volvocine: contractile vacuoles, stigma, a single pyrenoid and urn-shaped chloroplastid, and nucleus are present. The protoplast of the cell figured as 22 contains two pyrenoids and two stigmas which indicates apparently that nuclear and cytoplasmic division are soon to follow. Unfortunately I was unable to observe division stages. Korschikoff (1925) describes reproduction as consisting of the division of the protoplast into two motile individuals which escape by the fission of the parent shell and secrete new shells for themselves.

SPONDYLOMORACEAE

CHLAMYDOBOTRYS STELLATA Korsch. (fig. 26).—As Smith (1933) points out, considerable confusion exists with reference to the occurrence of members of Chlamydobotrys in the United States, since they have sometimes been confused with Spondylomorum quaternarium which regularly has cells with four flagella. The figure of Chlamydobotrys gracilis reproduced as 232 by Smith (1933) and copied from an unpublished drawing of Professor Hazen, is based on material collected near London, England, so that there are, so far as I am aware, no published records of occurrence of the genus Chlamydobotrys in the United States except Mast's (1918) report of a biflagellated "Spondylomorum quaternarium." In a preliminary contribution (Bold, 1933) I reported finding C. gracilis Korsch. in barnyard puddles in Maryland. Subsequent observations convince me that the organism is really C. stellata Korsch., since it regularly occurs in the eight-celled condition and the stigmas tend to be anterior or equatorial rather than posterior. In addition the cell wall is drawn out into a distinct process posteriorly, which is typical of C. stellata. The cells in my specimens were about 15.4 microns in length and approximately half that width at the widest point (fig. 26).

Explanation of Plates 6 and 7

All figures were drawn with a camera lucida and 1.9 mm. oil immersion objective, N.A. 1.30, and a 10× compensating ocular. Figure 11 is from a stained preparation; all other figures are from living cells. The drawings are reproduced without reduction and the magnifications are as follows: Figs. 1-10 and 12 are drawn with a magnification of 1200 \times ; Figure 11 approximately 1425 \times ; figures 13-26 1500 \times .

Plate 6

Pyramimonas montana Geitler

- Fig. 1. Vegetative individual in surface view.
- Fig. 2. Vegetative individual in median optical section.
- Fig. 3. Anterior view of a vegetative individual.
- Fig. 4. An encysted individual.
- Figs. 5-10 and 12. Stages in asexual reproduction.
- Fig. 11. Cell fixed in corrosive sublimate and stained in Haidenhain's haematoxylin.

Chlamydomonas schizochlora Bold

- Fig. 13. Vegetative individual with stigma in surface view.
- Fig. 14. Vegetative individual in anterior view.
- Fig. 15. Vegetative individual rotated about 90°, stigma in edge view.

Plate 7

Carteria crucifera Korsch

- Fig. 16. Vegetative individual.
- Fig. 17. Four daughter cells.

Carteria ellipsoidalis Bold

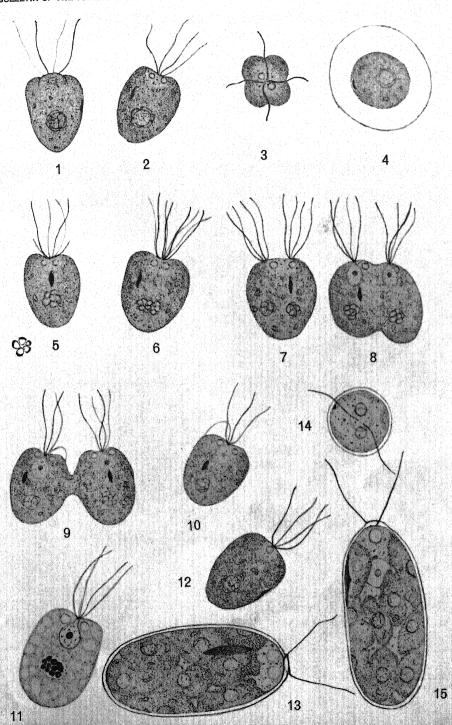
- Fig. 18. Vegetative individual in median optical section; surface view of pyrenoid.
- Fig. 19. Anterior aspect of vegetative individual.
- Fig. 20. Eight daughter cells.

Chlamydomonas metastigma (Stein) Gorosch

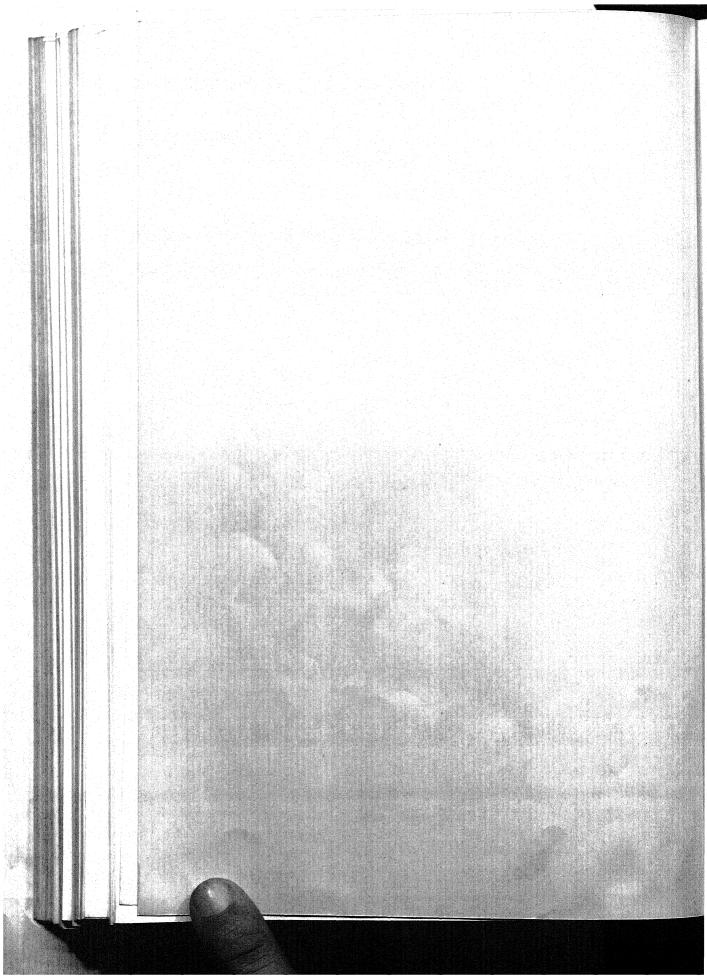
Fig. 21. Vegetative individual.

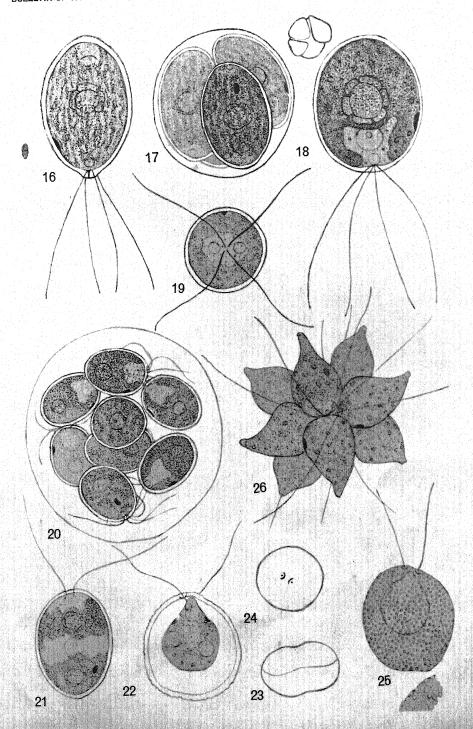
Dysmorphococcus variabilis Takeda

- Fig. 22. Vegetative individual preparing for division, median optical section.
- Fig. 23. Posterior view of lorica.
- Fig. 24. Anterior view of lorica showing flagellar apertures.
- Fig. 25. Surface view of a vegetative individual; detail of shell structure. Chlamydobotrys stellata Korsch.
- Fig. 26. Vegetative colony.

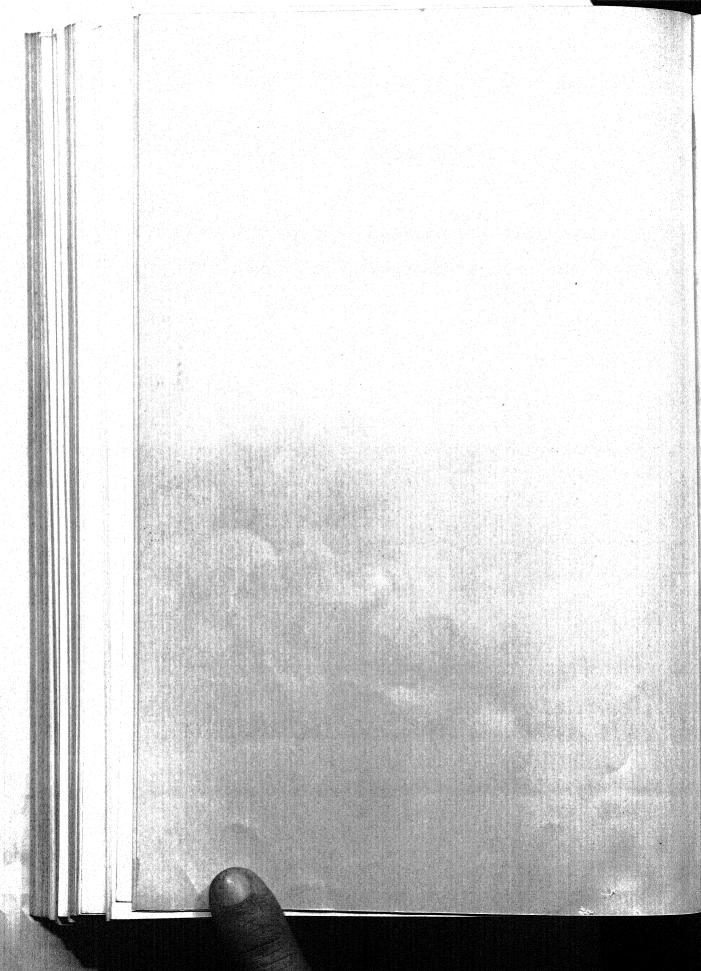


BOLD, MARYLAND ALGAE





BOLD, MARYLAND ALGAE



SUMMARY

1. Two new species, namely Carteria ellipsoidalis and Chlamydomonas schizochlora are described and figured from Maryland.

2. Five species are reported for the first time as occurring in the United States. They are: Pyramimonas montana Geitler, Carteria crucifera Korsch., Chlamydomonas metastigma (Stein) Gorosch., Dysmorphococcus variabilis Takeda, and Chlamydobotrys stellata Korsch.

3. Asexual reproduction of *Pyramimonas montana* is described in detail.

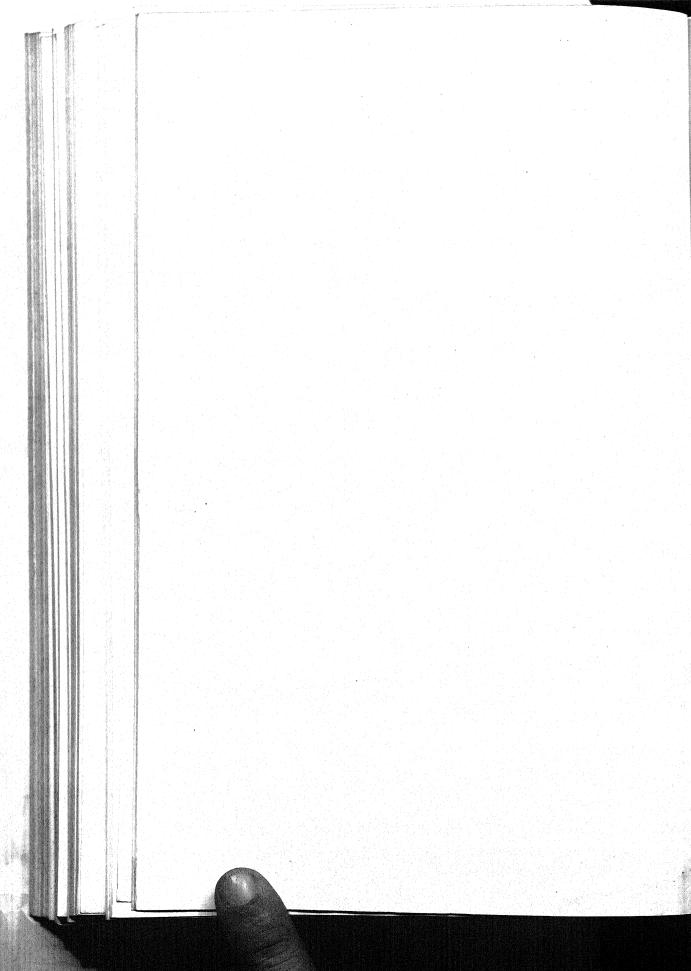
In conclusion the author wishes to express his gratitude to Professor Tracy E. Hazen of Columbia University for criticisms and suggestions.

DEPARTMENT OF BIOLOGY, VANDERBILT UNIVERSITY

Literature cited

- Bold, H. C. 1933. Some interesting algae from tidewater Maryland. Journ. Tenn. Acad. Sci. 11: 93-94.
- Geitler, L. 1925. Zur Kenntniss der Gattung Pyramidomonas. Arch. Protistenk. 52: 356-370.
- Goreschankin, J. N. 1891. Beiträge zur Kenntniss der Morphologie und Systematik der Chlamydomonaden. II. *Chlamydomonas Reinhardi* (Dang.) und sein Verwandten. Bull. Soc. Imp. Nat. Moscou 5: 101-138.
- Korschikoff, A. A. 1925. Beiträge zur Morphologie und Systematik der Volvocales. Russ. Archiv. Protistenk. 4: 153–197.
- Mast, S. O. 1918. Effects of chemicals on reversion in orientation to light in the colonial form, Spondylomorum quarternarium. Journ. Exp. Zool. 26: 503-520.
- Pascher, A. 1927. Die Süsswasserflora Deutschlands, Österreichs und der Schweiz. Heft 4, Volvocales, 506 pages, Jena.
- Prescott, G. W. 1927. The motile algae of Iowa. Univ. of Iowa Studies 12: 1-40. Smith, G. M. 1933. The freshwater algae of the United States. 716 pp. New
- York.

 Takeda, H. 1916. Dysmorphococcus variabilis, gen. et sp. nov. Ann. Bot. 30: 151156.



Pteridophyta of the Galapagos and Cocos Islands¹

H. K. Svenson (WITH PLATES 8 TO 10)

The basis for the materials of this paper is the collection made by the Astor Expedition to these islands in 1930 (specimens in herb. Brooklyn Botanic Garden), the phanerogams of which have already been reported upon.2 Through the kindness of Mr. John S. L. Gilmour, now assistant director of the Royal Botanic Gardens at Kew, arrangements were made in 1933 to examine Darwin's specimens collected on the memorable voyage of the Beagle, now incorporated in the general herbarium of the University of Cambridge, and representing the first record of ferns from the Galapagos Islands. All of these were found with the exception of the unimportant Asplenium subulatum. In addition, through the kindness of Mr. Gilmour and with the help of Mr. Ballard, the collections of Captain Wood and Captain Markham, cited by Moore in Index Filicum and by Sir W. J. Hooker in Species Filicum were examined at Kew. Since genera and species have been much altered in the past century, a considerable amount of search was often necessary in locating these old specimens, but nearly all of any great interest were uncovered.

Mr. C. A. Weatherby, Senior Curator of the Gray Herbarium, has given me kindly assistance throughout my investigations. To Dr. W. R. Maxon, of the United States National Herbarium, I have been much indebted for determination of difficult species, for good advice, and for correction of occasional determinations; and to Mr. C. V. Morton of the same institution I am also indebted for help. Dr. H. A. Gleason of the New York Botanical Garden has been most kind in lending specimens from the large South American collections at that institution. Mr. John Thomas Howell of the California Academy of Sciences has most generously given me duplicates from Stewart's collection from the Galapagos Islands, and has lent me many of Stewart's critical specimens not represented in other herbaria. The abbreviations for herbaria used in the citation of specimens, I believe, are obvious.

While every effort has been made to include all important records of pteridophytes from the Galapagos Islands, thereby providing a survey of the pteridophyte flora, no such attempt is just at present being made for the ferns of Cocos Island. Despite extensive exploration, some of the ferns of Captain Wood's collection have never since been noted from the

¹ Brooklyn Botanic Garden Contributions. No. 83.

² Am. Journ. Bot. 22: 208-277 (1935).

Galapagos Islands, and I strongly suspect that such specimens were obtained elsewhere, probably on the continent of South America. They were undoubtedly erroneously ascribed to the Galapagos Islands through mixture of localities after the tragic death of Edmonston,³ the botanist accompanying the *Pandora* (Commander, Captain Wood), which explored the Galapagos Islands in company with the *Herald*. According to Dr. Robinson (p. 221), 44 ferns were received at Kew in 1854, and the identifications by Sir W. J. Hooker were noted in scattered citations throughout *Species Filicum*. The specimens which I suspect were collected elsewhere than in the Galapagos Islands are as follows:

Adiantum Alarconianum	Cyclopeltis semicordata
" patens	Dryopteris glandulosa var. brachyodus
" tetraphyllum	" rudis
Ananthocorus angustifolius	Histiopteris incisa
Asplenium laetum	Polypodium loriceum
" rutaceum	" percussum
" serratum	Pteris propinqua var. Cumingiana

With elimination of these species, the relationships of the pteridophyte flora of the Galapagos Islands may be discussed. Since they are desert islands with moist conditions only on the windward uplands, the number of species (66) is comparatively meagre. Of the three recognized endemics, Asplenium carolinum is scarcely more than a form of the widespread A. formosum. The second, Polypodium pleiosorus of Darwin's collection (now to be placed in Dryopteris), inhabits the moist summits of James and Chatham Islands, and is close to the polymorphic West Indian and Andean D. subincisa. Notholaena galapagensis, to be described in this paper, a species of dry rocks and a relative of the Mexican N. candida, is perhaps the same as one or two nondescript Peruvian or Chilian collections.

Several species are of restricted range. Polypodium tridens, long passing under P. squamatum, is found also on the adjacent coast of Ecuador. Asplenium poloense, described from the Bolivian Andes and belonging to the difficult lunulatum-group, is probably more widespread than available collections indicate. Undoubtedly the most spectacular of Galapagos ferns is Trachypteris pinnata, a "resurrection" fern not uncommon on rocky banks, and a member of a genus with only three known species: the Galapagos plant, an inhabitant also of the Bolivian and Peruvian Andes; T. Gillianum from eastern Brazil and adjacent Argentina; and T. Drake-

³ Thomas Edmonston (1825–1846), a native of the Shetland Islands, was killed by accidental gunshot on boarding a boat in the surf at Sua near Atacamas on the Ecuadorean mainland (cf. The Phytologist 2: 580 (1846)).

ana, only recently described by Christensen⁴ from Madagascar. The remainder of the species, except for a tree-fern (Hemitelia aff. subcaerulea), a member of a group notorious for its restricted and isolated species, appear to be wide-ranging.

The following pteridophytes (40) are common to the Galapagos Islands

and the West Indies:5

Acrostichum aureum	Hypolepis repens
Adiantum concinnum	Nephrolepis biserrata
" macrophyllum	Pityrogramma calomelanos
" petiolatum	Polypodium angustifolium
" villosum	" aureum
Asplenium auritum	" crassifolium
" cristatum	" lanceolatum
" formosum (A. carolinum)	" pectinatum
" myriophyllum	" Phyllitidis
" pumilum	" polypodioides
" Serra	Polystichum adiantiforme
Blechnum occidentale	Pteris biaurita (P. quadriaurita)
" unilaterale	Tectaria martinicensis
Cheilanthes microphylla	Trichomanes Krausii
Doryopteris pedata	Lycopodium cernuum
Dryopteris gongylodes	" dichotomum
" patens	" reflexum
" Poiteana	" taxifolium
" tetragona	Psilotum nudum
Elaphoglossum petiolatum	
Hymenophyllum ciliatum	

Cocos Island (off the coast of Costa Rica) and the Galapagos Islands have a number of pteridophytes in common. Though only three miles in diameter, Cocos has a high proportion of ferns (22 species were collected by the Astor Expedition), due to the heavy covering of tropical rain forest. The following species (8) are found on both the Galapagos and Cocos Islands.

Acrostichum aureum Adiantum petiolatum Nephrolepis biserrata pectinata Pityrogramma calomelanos Polypodium aureum Phyllitidis Polystichum adiantiforme

Several widely distributed tropical pteridophytes (19) are known from the Galapagos Islands and Madagascar (cf. Christensen, l.c.):

⁴ Dansk Bot. Arkiv 7: 111. t. 42 (1932).

⁵ Cf. Domin, The Pteridophyta of Dominica, Roy. Czech. Soc. Nat. Hist. Mém. n. ser. no. 2 (1929); Maxon, Surv. Porto Rico and Virgin Ids. 6: 373-521 (1926).

Acrostichum aureum Anogramma leptophylla Asplenium auritum

formosum (A. carolinum)

" praemorsum

Dryopteris gongylodes
"mollis

Elaphoglossum petiolatum Gleichenia linearis

Hymenophyllum ciliatum

Nephrolepis biserrata Pityrogramma calomelanos Polypodium lanceolatum Polystichum adiantiforme Pteris quadriaurita (P. biaurita)

Lycopodium cernuum clavatum

" complanatum

Psilotum nudum

In the Galapagos Archipelago, the distribution of ferns is probably much the same on all the larger islands. As is the case with the flowering plants of Indefatigable Island,6 different species of ferns are progressively seen as one ascends the moist mountain slopes from the desert areas of the coast, and a similar progression probably occurs on the windward side of all the larger islands. At Academy Bay, on the south (and moist) side of Indefatigable Island the first fern to be encountered is Notholaena galapagensis, which is abundant on the escarpment at about 100 ft. elevation. Exposed lava banks soon reveal the rosettes of Trachypteris pinnata, a species which reaches its maximum development on rocks and logs in the damper woodlands. At about 500 ft. Asplenium auritum and Polypodium lepidopteris cluster on tree trunks with Tillandsia insularis and the orchid, Ionopsis utricularioides. At this elevation, by brushing aside grasses and shrubbery, one can readily disclose Doryopteris pedata, Asplenium carolinum, and Polypodium tridens beneath the shade of jagged lava fragments. When the densest vegetation is reached, at about 800 ft., bird's-nest ferns (Polypodium Phyllitidis) and maidenhair ferns (Adiantum Henslovianum) are not uncommon in the underbrush. A little higher, in the cleared areas of the plantation Fortuna, a strong growth of Hypolepis repens and occasional plants of Adiantum villosum are encountered, perhaps owing their presence to human habitations. On the steep mountain slope above the plantation, overhanging boulders provide shaded spots suitable for the growth of Adiantum macrophyllum, and for the yellowpowdered fronds of Gymnogramme tartarea. Toward the summit, at an altitude of about 2,000 ft.—the highest point our party was able to reach the dwarfed trees are festooned with liverworts and epiphytic lycopodiums, on the ground there are banks of Blechnum unilaterale and Nephrolepis pectinata, and in openings tall brakes of Pteridium arachnoideum are not uncommon.

⁶ Cf. Tabular view of Altitudinal Distribution, Am. Journ. Bot. 22: 210-211 (1935).

Bibliographical references occurring frequently in the text are abbreviated as fol-

Rob. (1). Robinson, B. L. Flora of the Galapagos Islands. Proc. Amer. Acad. 38: 77-269, 3 pl. (1902).

Stewart (1). Stewart, A. A botanical survey of the Galapagos Islands. Proc. California Acad., ser. 4, 1: 7-288, 19 pl. (1911).

Stewart (2). Stewart, A. Notes on the botany of Cocos Island. Proc. California

Acad., ser. 4, 1: 375-404, 4 pl. (1912).

The collections by Rorud were cited in E. Christophersen, Nyt. Mag. for Naturvidenskaberne 70: 69-70 (1932), and were determined by Dr. Christensen. Moore's references to Galapagos ferns and early citations by Andersson, Caruel, etc. will be found in Dr. Robinson's account.

FILICES⁷

ACROSTICHUM L.

A. AUREUM L. Sp. Pl. 1069 (1753); Rob. (1), 104; Stewart (1), 11.— ALBEMARLE ISL.: Villamil, 3150 ft., Stewart. GALAPAGOS IDS.: Capt. Wood, two sheets of rather young material.

ADIANTUM L.

*A. Alarconianum Gaud. Voy. Bon. Bot. t. 99 (1846); Stewart (1), 11. A. incisum Presl; Rob. (1), 105.—GALAPAGOS IDS.: Capt. Wood, two sheets of branched specimens (as A. incisum Presl).

A. CONCINNUM H. & B. in Willd. Sp. 5: 451 (1810); Rob. (1), 105; Stewart (1), 11. A. cuneatum sensu Hook.f. Trans. Linn. Soc. 20: 168 (1847), not Langsd. & Fisch. A. aethiopicum sensu Moore, Ind. Fil. 19: (1857), not L.; Rob. (1), 105; Stewart (1), 11.—Abingdon Isl.: Snodgrass & Heller; Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Charles ISL.: Stewart. Indefatigable Isl.: Rorud. James Isl.: Darwin; Scouler; Snodgrass & Heller. NARBOROUGH ISL.: Snodgrass & Heller (?). GALA-PAGOS IDS.: Douglas (Kew).

Darwin's collection is typical A. concinnum. The specimen of A. aethiopicum, collected by Douglas, and evidently the basis of Moore's citation, is without question a small, poor specimen of the same species.

It has a perfectly smooth rachis and a few very old sori.

A. HENSLOVIANUM Hook.f. Trans. Linn. Soc. 20: 169 (1847); Rob. (1), 105; Stewart (1), 11. A. parvulum Hook.f. Trans. Linn. Soc. 20: 168 (1847). A. diaphanum sensu Stewart (1), 11; not Bl.—Abingdon Isl.: Stewart. ALBEMARLE ISL.: Stewart, including no. 785 (Cal) (as A. diaphanum).

⁷ Species marked by an asterisk (*) are probably not from the Galapagos Islands Previous inclusion in the flora is probably due to Edmonston's confused data. (See introduction, p. 304.)

CHARLES ISL.: Darwin (4 specimens). CHATHAM ISL.: Baur; Stewart no. 784 (US) (as A. concinnum). Indefatigable Isl.: Stewart; Academy Bay, wet shady places among rocks, 1100-1500 ft., Svenson no. 144. James Isl.: Darwin; Stewart.

Darwin's specimen of Adiantum parvulum (from Charles Island) is a very small example with pinnules not exceeding 10 mm. × 4 mm. and none have more than one or two sori. The shiny, almost black stipe has somewhat clavate scurf, exactly as in A. Henslovianum. The material reported by Stewart as Adiantum diaphanum is very young but shows under microscopic examination the indusia characteristic of A. Henslovianum, and the same type of scurfy rachis.

A. MACROPHYLLUM Sw. Prod. 135 (1788); Stewart (1), 12.—Albemarle ISL.: Stewart. Indefatigable Isl.: Stewart; Rorud. James Isl.: Stewart. Young fronds of this species, of a translucent, pinkish color, were noted but not collected, beneath damp boulders at about 1,000 ft. elevation at

Academy Bay.

*A. PATENS Willd. Sp. 5: 439 (1810); Stewart (1), 12.—GALAPAGOS IDS.: Capt. Wood. The specimen which I saw at Kew is identical with Schlim no. 616 from Ocaña, New Granada, and very close to Seeman no. 1448 from Mexico.

A. PETIOLATUM Desv. Berl. Mag. 5: 326 (1811); Stewart (1), 12. A. Kaulfussii Kunze, Linnaea 21: 221 (1848); Rob. (1), 105.—CHATHAM Isl.: Capt. Wood (Kew), a specimen of apparently typical material.

*A. TETRAPHYLLUM H. & B. in Willd. Sp. 5:441 (1810); Stewart (1), 12. A. prionophyllum HBK Nov. Gen. & Sp. 1: 20 (1815); Rob. (1) 106.— CHATHAM ISL.: Capt. Wood, two sheets identical with Lehmann no. 7685.

A. VILLOSUM L. Syst. Nat. ed. 10, 2: 1328 (1759).—INDEFATIGABLE Isl.: Academy Bay, in cut-over places in vicinity of the Plantation Fortuna, 800 ft., Svenson no. 101; Academy Bay, 500 ft., Stewart no. 798 (G) (as E. petiolatum). My collection is in excellent agreement with Schkuhr's plate.

Anogramma Link

A. CHAEROPHYLLA (Desv.) Link, Fil. Sp. 138; (1841) Stewart (1), 12. Gymnogramma chaerophylla Desv. Berl. Mag. 5: 305 (1811); Rob. (1), 109.—CHARLES ISL.: Darwin, the specimen is in good condition and unquestionably A. chaerophylla.

A. LEPTOPHYLLA (L.) Link, Fil. Sp. 137 (1841); Stewart (1), 12. Gymnogramma leptophylla Desv. Berl. Mag. 5: 305 (1811); Rob. (1), 109.—CHARLES ISL.: Baur.

Ananthocorus Underw. & Maxon

*A. ANGUSTIFOLIUS (Sw.) Underw. & Maxon, Contr. U. S. Nat. Herb. 10: 487 (1908). Vittaria angustifolia (Sw.) Bak. Fl. Bras. 1²: 544 (1870); Stewart (1), 27. Pteris angustifolia Sw. Prod. 129 (1788). Taenitis angustifolia Spr. Syst. 4: 42 (1827); Hook. Sp. Fil. 5: 187 (1864); Rob. (1), 115.—GALAPAGOS IDS.: Capt. Wood, the specimen (cited by Hooker) has fronds 3 dm. long, and as much as 8 mm. wide.

ASPLENIUM L.

A. AURITUM Sw. in Schrad. Journ. 1800²: 52 (1801); C. Chr. Archiv. f. Bot. 9¹¹: 16, t. 1, fig. 1 (1910); Rob. (1), 106; Maxon, Bot. Porto Rico & Virgin Ids. 6: 450 (1926); Domin, Pterid. Dominica 176 (1929). A. sulcatum Lam. Encyc. 2: 308 (1786); Stewart (1), 15. A. marinum var. auriculatum Hook.f. Trans. Linn. Soc. 20: 170 (1847). A. auritum var. macilentum Moore, Ind. Fil. 115 (1859); Rob. (1), 107. A. lunulatum sensu Rob. (1) 107; not Sw.—Abingdon Isl.: Snodgrass & Heller; Stewart. Albemarle Isl.: Stewart. Charles Isl.: Darwin; Andersson; Agassiz; Stewart. Charlam Isl.: Capt. Wood; Stewart. Indefatigable Isl.: Stewart; Svenson. James Isl.: Darwin; Stewart; Rorud (var. macilentum).

Much variation is shown in Captain Wood's collection at Kew. One of his specimens (Chatham Isl.) with somewhat dissected pinnae and the accompanying query "rigidum?" strongly resembles Stewart's no. 812 (James Isl.) but is far removed from A. rigidum as illustrated by Christensen (l.c.). The third collection, labeled merely "Galapagos Islands," is a small var. macilentum with small obtuse pinnae and no trace of auricles.

Domin (l.c.) notes that var. macilentum is abundant in Jamaica at an altitude of from 5,000 to 6,000 ft. on exposed rocks. From personal observation I cannot see that the variations displayed in the Galapagos Islands are significant from the point of view of geographical distribution. Of the three collections of this abundant epiphyte which I made on Indefatigable Island, no. 53 (500 ft. altitude) verges toward var. macilentum; no. 100 (700 ft.) is nearer the type; and no. 97 (2,000 ft.) is var. macilentum. The specimens cited by Christophersen, determined by Christensen as "var. macilentum" came two kilometers from the shore, on James Island. None of the specimens which I have seen are characterized by a "rachis broadly winged," stated by Hooker & Baker (Syn. Fil. 208 (1873)) as one of the characteristics of A. macilentum.

Lee's specimens of A. lunulatum (U. S. Nat. Herb.) are, according to a communication from Dr. Maxon, representative specimens of A. auritum. Darwin's collections are of the typical form.

A. FORMOSUM Willd. Sp. 5: 329 (1810); Rob. (1), 107; Stewart (1), 13. A. carolinum Maxon, Contr. U. S. Nat. Herb. 17: 148 (1913). A. subalatum Hook. & Arn. Bot. Beech. Voy. 312, t. 71 (1840); Hook.f. Trans. Linn. Soc. 20: 169 (1847) (as A. subulatum); Andersson, [Eugenies Resa, Bot.] Kgl. Sv. Vet. Akad. Handl. 1853: 131 (1854) and 1857: 41 (1861).—Abingdon Isl.: Snodgrass & Heller; Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Darwin; Capt. Markham (Kew), labeled "11-80"; Lee; Baur; Stewart. Charlam Isl.: Capt. Wood; Cuming (Kew); Stewart. Indefatigable Isl.: Stewart; Rorud; Academy Bay, common in leaf mould in rocky woods, 500 ft., Svenson no. 75. James Isl.: Stewart. Narborough Isl.: Stewart.

"Asplenium subulatum" Hook.f. was the only specimen of the Darwin

collection which I was unable to find at Cambridge.

A. CRISTATUM Lam. Encyc. 2: 310 (1786); Stewart (1), 13. A. cicutarium Sw. Prod. 130 (1788). A. rhizophyllum sensu Rob. (1), 107, not Kunze. A. Macraei sensu Hook.f. Trans. Linn. Soc. 20: 169 (1847), not Hook. & Grev. A. myriophyllum sensu Stewart (1), 14, not (Sw.) Presl.—Abingdon Isl.: Stewart. Albemarle Isl.: Stewart. Chatham Isl.: Capt. Wood; Baur; Stewart. Indefatigable Isl.: Stewart; Rorud; Academy Bay, common among rocks in shade of shrubs and vines, 800 ft., Svenson no. 108. James Isl.: Darwin; Stewart.

Identity of the Galapagos plants has been greatly confused due to merging of the perfectly distinct A. Macraei of the Hawaiian Islands and Cocos Island with A. rhizophyllum, and confusion of A. cristatum (A.

cicutarium) of the Galapagos Islands with A. rhizophyllum.

Two specimens of A. cristatum at Kew were collected on Chatham Island by Captain Wood. One of these is labeled A. rhizophyllum, (a distorted specimen partially covered with liverworts and mounted with Jameson no. 28 from Quito); the other is labeled A. Macraei and mounted on a sheet of that species. Darwin's collection at Cambridge (consisting of two sheets labeled A. Macraei) is also A. cristatum. These collections of Darwin and Capt. Wood are the only basis for Stewart's citation of A. myriophyllum.

*A. LAETUM Sw. Syn. Fil. 79, 271 (1806); Rob. (1), 107; Stewart (1), 14.—Chatham Isl.: Capt. Wood. This specimen, the only record for the Galapagos Islands, has pinnae 2.5-3 cm. long and 0.8-1.0 cm. broad, the margin sharply but somewhat irregularly serrate. The species is abundant in the West Indies (cf. Domin, Pter. Dominica 174, (1929)), and in continental America extends from Mexico to Southern Brazil.

A. MYRIOPHYLLUM (Sw.) Presl, Rel. Haenk. 1: 48 (1825).—INDEFATIGABLE ISL.: In the forest, the moist region, 255-300 m., Rorud no. 254.

(Specimen (det. Christensen) examined through the kindness of Dr. Erling Christophersen).

A. POLOENSE Rosenst. in Fedde, Rep. Spec. Nov. 12: 469 (1913).—
INDEFATIGABLE ISL.: Academy Bay, south slope of the mountain on vertical damp ledges in stream bed, 1000–5000 ft., Svenson no. 130. The rachis is slightly channeled and compressed-sulcate at base; the shiny subulate scales are deep brown with clearly-defined reticulation at the apex. A. poloense is a Bolivian species known previously only from Buchtien's no. 3345, collected in "Yungas septentrionalis, Polo-Polo prope Coroico, 900 m. alt." It is said to be related to A. pulcherrima Raddi (?A. pulchellum) and in its strongly auriculate and deeply incised pinnae it approaches A. Fernandezianum Kze.

A. PRAEMORSUM Sw. Prod. 130 (1788); Stewart (1), 14. A. furcatum Thunb. Prod. Fl. Cap. 172 (1800); Hook.f. Trans. Linn. Soc. 20: 169 (1847); Rob. (1), 107.—Albermarle Isl.: Snodgrass & Heller; Stewart. James Isl.: Darwin; Stewart. Narborough Isl.: Stewart. Indefatigable Isl.: Stewart; Academy Bay, a common epiphyte at 1,400–1,500 ft. Svenson no. 128, and 2,000 ft. (no. 211). I did not see Capt. Wood's collection cited by Hooker, Sp. Fil. 3: 167 (1860). A species of wide tropical distribution.

A. PUMILUM Sw. Prod. 129 (1788); Stewart (1), 14.—CHARLES ISL.: Stewart. Indefatigable Isl.: Stewart. Stewart's collections closely re-

semble Small's illustration in Ferns of Florida: 133 (1931).

*A. RUTACEUM (Willd.) Metten. Abh. Senck. Nat. Gesell. Frankfurt 3: 129, t. 5, fig. 32-33 (1859); Rob. (1), 108; Stewart (1), 14.—CHATHAM ISL.: Capt. Wood. The specimen is identical with Moritz no. 402 from Tovar Colombia (K).

A. SANGUINOLENTUM Kunze ex Mett. Abh. Senck. Nat. Gesell. Frankfurt 3: 142, t. 4, fig. 10 (1859). A. nigrescens Hook.f. Trans. Linn. Soc. 20: 170 (1847), not Blume (1828). A. nubilum Moore Ind. Fil. 150 (1859). A. anisophyllum var. latifolium Hook.f., Sp. Fil. 3: 111 (1860); Rob. (1), 106; Stewart (1), 13. A. sarcodes Maxon, Contr. U. S. Nat. Herb. 10: 494, t. 56, fig. 3 (1908). A. anisophyllum var. sanguinolentum Hieron. Hedwigia 47: 226 (1908).—Albemarle Isl.: Capt. Wood; Stewart no. 857 (G), (as A. Serra). Chatham Isl.: Stewart no. 858 (G, Cal, NY) (as A. Serra). Indefatigable Isl.: Academy Bay, 1000–1600 ft., plants 3 ft. high with a prominent blackened base, Svenson nos. 125, 221. James Isl.: Darwin; above 2000 ft., Stewart nos. 860 (Cal), 861 (Cal, G) (as A. Serra).

⁸ Moore's name appeared in December, 1859. Maxon (l.c.) gives the year, 1860, for Mettenius' publication, but in a later treatment (Bot. Porto Rico & Virgin Isls. 6³: 449 (1926)), the date appears as 1859, which would undoubtedly be earlier than the issue of Moore's name.

The two sheets of Darwin's collection (upon which the name A. nubilum was based) are substantially the same as mine and identical with material from Cuba, and with Maxon's figure of A. sarcodes. The latter species has already been placed in synonymy under the wide-spread A. sanguinolentum by Christensen.

*A. Serra Langsd. & Fisch. Icon. Fil. 16, t. 19 (1810); Rob. (1), 108; Stewart (1), 15.—Albemarle Isl.: Stewart nos. 856, 857 (Cal). Duncan Isl.: Stewart no. 859 (Cal). Galapagos Ids.: Capt. Wood; no definite

locality is given on the label.

A. SERRATUM L. Sp. Pl. 1079 (1753); Rob. (1), 108; Stewart (1), 15.—Chatham Isl.: Capt. Wood. The specimen at Kew is representative of this large bird's-nest fern.

BLECHNUM L.

B. OCCIDENTALE L. Sp. Pl. 1077 (1753); Rob. (1), 108; Stewart (1), 16.—Abingdon Isl.: Snodgrass & Heller; Stewart. Albermarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Andersson; Stewart. Charlem Isl.: Chierchia; Baur. Duncan Isl.: Stewart. James Isl.: Darwin; Stewart. Darwin's specimen is typical. Capt. Wood's collection, cited as var. caudatum by Hooker (Sp. Fil. 3:51 (1860)) consists of two specimens neither of which is labeled as the variety. One is a loose poorly-dried plant, with pinnae up to 10 cm. long and 12 mm. wide; the other has pinnae 2-3 cm. long, 5 mm. wide.

B. UNILATERALE Sw. Berl. Mag. 4:79, t. 3, fig. 1 (1810); Maxon, Bot. Porto Rico & Virgin Isl. 63:456 (1926). B. blechnoides (Lag.) C. Chr. Ind. 151 (1905); Stewart (1), 15.—CHATHAM ISL.: Wreck Bay, 1700–2000 ft., Stewart. INDEFATIGABLE ISL.: Academy Bay, and epiphyte on the south slope of the mountain, alt. 2000 ft., Svenson no. 148, and not uncommon on the ground, alt. 2000 ft., Svenson no. 210.

CHEILANTHES Sw.

C. MICROPHYLLA Sw. Syn. 127 (1806); Rob. (1), 108; Stewart (1),16; Maxon, Contr. U. S. Nat. Herb. 24: 52 (1922). C. heterotricha Andersson, [Eugenies Resa Bot.] Sv. Vet. Akad. Handl. 1853: 129 (1854).—Abingdon Isl.: Stewart. Albemarle Isl.: Snodgrass & Heller; shady place near shore, Stewart. Charles Isl.: Andersson; Stewart. Charles Isl.: Baur. Indefatigable Isl.: Stewart; Academy Bay, dry places along trails, 300 ft., Svenson no. 256. Galapagos Ids.: Capt. Wood (Kew), a specimen labeled "Pellaea?", identical with Stewart no. 875 (Kew) from Albemarle Island.

C. MYRIOPHYLLA Desv. Berl. Mag. 5: 328 (1811); Rob. (1), 109; Stewart (1), 17.—Albemarle Isl.: Snodgrass & Heller.

CYCLOPELTIS J. Sm.

*C. SEMICORDATA (Sw.) J. Sm. in Curtis, Bot. Mag. 72: Comp. 36 (1846); Stewart (1), 17. Aspidium semicordatum Sw.; Rob. (1), 106.—GALAPAGOS IDS.: Capt. Wood (Kew); two sheets.

DENNSTAEDTIA Bernh.

D. aff. GLOBULIFERA (Poir.) Hieron. in Engler, Bot. Jahrb. 34: 455 (1904). *Polystichum apiifolium* sensu Stewart (1), 26; not (Sw.) C. Chr.—JAMES ISL.: occasional at 2000 ft. *Stewart* nos. 882, 883.

DICRANOPTERIS Bernh.

D. LINEARIS (Burm.) Underwood, Bull. Torrey Club 34: 250 (1907). Gleichenia linearis (Burm.) Clarke, Trans. Linn. Soc. 2: Bot. 1: 428 (1880); Stewart (1), 20. G. dichotoma Hook. Sp. Fil. 1: 12 (1846); Rob. (1), 109.—Chatham Isl.: Stewart. Duncan Isl.: Stewart. Galapagos Ids.: Capt. Wood. This collection, probably representing the citation by Moore (Ind. Fil. 376 (1862)), is the same as Stewart's collections, but a larger specimen. The exact identity of this material is uncertain.

DIPLAZIUM Sw.

D. aff. SUBOBTUSUM Rosenstock in Fedde, Rep. Spec. Nov. 7: 296 (1909).—Indefatigable Isl.: Academy Bay, plants 4-5 ft. high, alt. 1625 ft., south slope of the mountain (*Svenson* no. 132) (Pl. 9, fig. 3). The segments are less acute than in *D. subobtusum*, which was described from a collection by Spruce (no. 4019) from Mt. Guayrapurina, Ecuador. It is related to *D. obtusum* Desv.

DORYOPTERIS J. Sm.

D. PEDATA (L.) Fée, Gen. Fil. 133 (1852); Stewart (1), 18. Pteris pedata L. Sp. Pl. 1075 (1753); Rob. (1), 114. Litobrochia pedata Presl; Hook. f. Trans. Linn. Soc. 20: 168 (1847).—Abingdon Isl.: Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Darwin; Andersson; Capt. Markham; Lee; Baur; Stewart. Charlam Isl.: Baur; Stewart. Indefatigable Isl.: Stewart; Rorud; Academy Bay, abundant in damp places among rocks, alt. 400 ft., Svenson no. 69. James Isl.: Darwin; Douglas; Cuming; Stewart.

The collection by Darwin from James Island represents young material without sori; that from Charles Island is mature. I have also seen the specimens obtained by Capt. Wood, Cuming, and Capt. Markham, but was unable to locate any specimen of *Doryopteris concolor* (*Pellaea ge-*

raniaefolia) cited by Hooker, Sp. Fil. 2: 133 (1858), nor did I find either at Cambridge or Kew any collection of D. pedata by Douglas. Since D. concolor (coll. Douglas) has never reappeared in any collection from the Galapagos Islands, it is probable that the specimen was confused with the similar D. pedata, or came from some other locality.

DRYOPTERIS Adans.

D. AMPLA (Willd.) O. Ktze. Rev. Gen. Pl. 2: 812 (1891); C. Chr. Vid. Selsk. Skr. ser. 8, 6¹: 49, fig. 9 (1920). Polypodium paleaceum Hook.f. Trans. Linn. Soc. 20: 166 (1847); Andersson, [Eugenies Resa Bot.] Sv. Vet. Akad. Handl. 1853: 126 (1854); Robinson (1), 112. Nephrodium paleaceum (Hook.f.) Diels, Nat. Pfl. 1⁴: 177 (1899). Dryopteris furcata (Kl.) O. Ktze. Rev. Gen. 2: 812 (1891); Stewart (1), 18.—Albemarle Isl.: Iguana Cove, Snodgrass & Heller no. 113 (G); lava caverns, Villamil, 1350 ft., Stewart no. 959 (NY); upper regions, Villamil, Stewart no. 965 (NY). Charles Isl.: Darwin; summit of the mountain, Andersson (G); Lee (US); Stewart. Chatham Isl.: southwest end, middle region, Baur no. 367 (G), (as Alsophila sp.); Wreck Bay, 650 ft., Stewart no. 960 (G). Indefatigable Isl.: Rorud; Academy Bay, 550 ft., Stewart no. 963 (G); Academy Bay, at the Plantation Fortuna, 800 ft., Svenson nos. 105, 106. James Isl.: Darwin; James Bay, 2750 ft., Stewart no. 962 (G, NY).

Darwin's collections are represented by two sheets; the specimens of Capt. Wood and Capt. Markham at Kew (without further locality) are poorly prepared, but unquestionably the same. D. ampla, according to Christensen (l.c.), is known from "the northern Andes of Venezuela, Colombia and Ecuador to Costa Rica and Guatemala, Jamaica and Cuba, from where it has found its way to Florida, and the southern Lesser Antilles from Trinidad to St. Vincent."

D. COLUMBIANA C. Chr. Vid. Selsk. Skr. 74: 279, fig. 8 (1907); Vid. Selsk. Skr. 102: 137 (1913).—Indefatigable Isl.: Academy Bay, damp openings at 1500 to 2000 ft., Svenson nos. 216 and 219. Charles Isl.: Stewart no. 909 (G) (as D. parasitica). Chatham Isl.: Capt. Wood (an unidentified specimen at Kew). Further distribution: Colombia, Panama.

The material which I have cited under this name is not exactly homogeneous, and it would perhaps be as well to have called it D. pilosula (Kl. et Karst.) Hieron. In fact it combines the characteristics of these two species as they are treated by Christensen, who was not at all times certain of their specific distinction. These terrestrial ferns of the Lastraea group do not appear to be abundant in the Galapagos Islands, being confined apparently to the moist, windward slopes of the mountains. However, I noted that they occurred fairly commonly from 1500 ft. to 2000 ft. eleva-

tion on Indefatigable Island, the fronds of specimens (no. 219) collected at the lower elevation being comparatively thin, and with the short rachis-pubescence of *D. columbiana*. The collection from 2000 ft. (no. 216), on the other hand, had distinctly coriaceous fronds, and the longer rachis-pubescence of *D. pilosula*. But the two types of rachis-pubescence often vary in fronds of the same clump, and indeed, in different portions of the same frond. The development of leathery texture is undoubtedly associated with the rapidly dwarfing character of the vegetation as one approaches the mountain-summits, and this leathery texture is probably correlated to Christensen's characterization of *Dryopteris ampla* as found in the Galapagos Islands (1920, p. 52), "At best it is a dwarfy form developed in exposed localities on the high mountains of the islands." Capt. Wood's collection closely resembles my no. 219.

The characteristic rigid hairs of *D. columbiana*, on the veins of the upper segment surface, are not particularly well developed in the Galapagos specimens (more developed in no. 216 than in no. 219), which tend also to be more pubescent than in the type collection of *D. columbiana* (NY). The apical portions of young fronds in the Galapagos specimens show very well the character of the indusium, which is reniform to ovate. The indusial hairs (5-9) are all marginal, except that a single one is frequently present in no. 216 at the upper surface, at the point of attachment of the indusium. The character of the indusium agrees, so far as I can make out with the type collection of *D. columbiana*, and not with *D. pilosula*, which tends to have a number of hairs on the upper indusial surface. The margin of the indusium is quickly folded up by the developing sporangia, and soon buried among the mature sporangia, so that the sorus often appears to be non-indusiate.

*D. GLANDULOSA (Desv.) C. Chr. var. BRACHYODUS (Kunze) C. Chr. Vid. Selsk. Skr. ser. 7, 10²: 172 (1913). D. brachyodus (Kze.) O. Ktze. Rev. Gen. Pl. 2: 812 (1891); Stewart (1), 18. Nephrodium brachyodon Hook. Sp. Fil. 4: 83 (1862); Rob. (1), 110.—Known only from the collection by Capt. Wood (Kew), where no further locality is given. Specimens are cited by Christensen from Guatemala to Colombia; the type coming from Pom-

payaco, Peru.

D. GONGYLODES (Schkuhr) O. Ktze. Rev. Gen. Pl. 2: 811 (1891); C. Chr. Vid. Selsk. Skr. ser. 7, 10²: 193 (1913). Nephrodium unitum R. Br.; Rob. (1), 110.

Listed by Dr. Robinson on the strength of Caruel's determination of Chiercha's collection. The species is close to D. mollis, and the Galapagos specimen probably represents either that species or D. columbiana.

D. dentata (Forsk.) C. Chr. Vid. Selsk. Skr. ser. 8, 61: 24 (1920). D.

Control of the second

mollis (Jacq.) Hieron. Hedwigia 46: 348 (1907); C. Chr. Vid. Selsk. Skr. ser. 7, 102: 191 (1913).—James Isl.: Stewart no. 915 (G) (as D. tricholepis). and perhaps some of his collections listed under D. parasitica. Lee's collection from Charles Island is doubtfully placed under D. mollis by Christensen (1913). By the same author (Dansk Bot. Arkiv. 7: 49 (1932)), and by Maxon, Bot. Porto Rico and Virgin Ids. 63: 470 (1926), D. mollis is treated as a synonym of D. dentata (Forsk.) C. Chr.

D. PATENS (Sw). O. Ktze., Rev. Gen. Pl. 2: 813 (1891); C. Chr. Ark. f. Bot. 911: 28, fig. 6 (1910) and Vid. Selsk. Skr. ser. 7, 102: 176 (1913). Nephrodium molle Schott, sensu Hook.f. (1), 171 (1847); Rob. (1), 110. Dryopteris parasitica (L.) O. Ktze., Stewart (1), 19, in large part.—Charles ISL.: 1000 ft., Stewart nos. 908 (K), 910 (NY). CHATHAM ISL.: Capt. Wood (K), as Nephrodium molle. Indefatigable Isl.: Rorud; Academy Bay, 850 ft., plants 4-5 ft. high, Svenson no. 133. JAMES ISL.: Darwin (as N. molle); James Bay, 2000 ft., Stewart no. 913 (K). Distributed throughout tropical America.

Dryopteris pleiosora (Hook.f.) n. comb. Polypodium pleiosorum9 Hook.f. Trans. Linn. Soc. 20: 166 (1847) (as pleiosoros); Rob. (1), 113; Stewart (1), 25. Nephrodium villosum sensu Rob. (1), 110; non Presl. Dryopteris villosa sensu Stewart (1), 20; non Ktze. Dryopteris tricholepis sensu Stewart (1), 19 (partim); non (Bak.) C. Chr.—James Isl.: Darwin (TYPE in herb. Cambridge Univ.). CHATHAM ISL.: Wreck Bay, common in moist places at 2000 ft., Stewart no. 914 (Cal, NY) (as D. tricholepis).

GALAPAGOS IDS.: Capt. Wood (as Polypodium Berteroanum).

Darwin's specimen, which I examined at Cambridge, is the same as Capt. Wood's at Kew, the latter being slightly more hairy on the lower surface. Stewart's specimen at the California Acadamy of Sciences represents an entire frond with scattered and comparatively few sori; that at New York is very small and immature, but fortunately has the entire base which shows the typical Ctenitis scales exceptionally well. Throughout the rachis these scales appear to be homogeneous, a deep glossy brown,

9 P. PLEIOSOROS, Hook. fil.; fronde ovatā bipinnatā, pinnis linearibus elongatis acuminatis; pinnulis lineari-oblongis approximatis apicibus rotundatis inferioribus grossè crenato-dentatis suprà pilis sparsis hirtis subtùs molliter pubescentibus, soris 10-14, rachibus costisque pubescentibus paleaceisque.

Hab. James Island, Charles Darwin, Esq.

Rachis paleacea pilisque brevibus albidis obsita, paleis elongatis brunneis. Pinnae 6 unc. longae, ad medium lineares deinde ad acumen gradatim attenuatae, 1 unc. latae. Pinnulae sub-50, $\frac{1}{2}$ - $\frac{2}{3}$ unc. longae, $\frac{1}{4}$ latae, sessiles, membranaceae v. subcoriaceae, supernè confluentes, suprà pubescentes, subtùs pilosae, pilis sparsis elongatis, marginibus supernè crenatae. Sori plurimi, medio venulae inter costam marginemque siti.

with well-developed marginal teeth. Short reddish articulate hairs occur abundantly on the lower surfaces of the frond, being replaced on the upper surfaces of the pinna-axis and the costules (especially on the nerves) by appressed subulate whitened hairs (of 4–6 cells, and averaging 0.2 mm. long), which make the surface somewhat glistening (at least in the Stewart specimens) and give a ciliate appearance to the margins of the segments. In addition, short two to three-celled hairs with a bulbiform apex (i.e. glandular) are found in mature segments (lacking in specimens at NY). The segments toward the middle of the frond are conspicuously crenatedentate.

Capt. Wood's specimen, cited with doubt by Hooker (Sp. Fil. 4: 270 (1862)) under *Polypodium Berteroanum*, was distinguished as follows: "submembranaceous, segments elongated, lobes shorter, lowest inferior often forming an axillary lobe between two segments, probably distinct." Hooker's judgment seems to have been correct; the Galapagos plant is quite different from *Dryopteris inaequalifolia* (Colla) C. Chr. Vidensk. Skr. ser. 8, 6¹: 73 (1920), [*Polypodium Berteroanum* Hook., not Sprengel] which is confined to Juan Ferandez, and has tripinnate fronds and prominent reddish scars on the stipe, left by the fallen scales. *D. tricholepis* (Bak.) C. Chr. is illustrated by Christensen (Vidensk. Selsk. Skr. ser. 7, 10²: 107, fig. 10d (1913)), and is obviously quite different from *D. pleiosora*, being an indusiate Guatemalan species with generally glabrous lower surfaces.

D. Poiteana (Bory) Urban, Symb. Ant. 4:20 (1903); C. Chr. Vidensk. Selsk. Skr. ser. 7, 10²: 265 (1913). Dryopteris reticulata sensu Stewart (1), 19; not (L.) Urban.—Indefatigable Isl.: Academy Bay, occasional in damp woods, 800 ft., Svenson no. 107; Academy Bay, above 550 ft., Stewart no. 900 (Cal). According to Christensen (l.c.), D. Poiteana is a wide-ranging species found in most of the West Indian Islands and from Guatemala to Peru.

*D. RUDIS (Kze.) C. Chr. Ind. 289 (1905); Stewart (1), 19. Polypodium rude Kze. Linnaea 13: 133 (1839); Hook. Sp. Fil. 4: 243 (1862). Known only from the citation by Hooker (l.c.) "Galapagos, Wood?," and I could

not locate the specimen at Kew.

D. TETRAGONA (Sw.) Urban, Symb. Ant. 4: 20 (1903). D. pseudotetragona Urban; Stewart (1), 19.—Indefatigable Isl.: the moist zone, December, 1926, Rorud no. 255; Academy Bay, in underbrush in damp places along trail, 700 ft., Svenson no. 117; Academy Bay, common in dense shade above 550 ft., Stewart no. 884 (Cal).

Christensen (l.c.) notes that the specimens collected by Miss Rorud are probably to be referred to a distinct form. The cutting of the pinnae

in no. 117 is very shallow, in this respect closely resembling the illustration of *D. Rolandii* C. Chr. Vid. Selsk. Skr. ser. 7, **10**²: 258, fig. 45 (1913). The sporangia are not spinescent as in *D. Rolandii*.

ELAPHOGLOSSUM Schott

E. PETIOLATUM (Sw.) Urban, Symb. Ant. 4: 61 (1903); Stewart (1), 20. Acrostichum muscosum sensu Rob. (1) 104; non Sw. A. viscosum Sw.; Rob. (1) 105. Elaphoglossum muscosum (Sw.) Moore; Stewart (1), 20.—Albemarle Isl.: Stewart no. 775 (Cal). (as E. muscosum). James Isl.: Darwin (two sheets). The specimen noted as Olfersia Langsdorfii by Hook. f. (Trans. Linn. Soc. 20: 167 (1847)), has a linear-elliptic fertile frond with a long portion of the stipe. No scales appear on the rachis or elsewhere. The second Darwin specimen bears the annotation "very near Acrostichum viscosum var. glabriusculum." Both should be included under E. petiolatum; apparently the scaly-stiped E. muscosum (Sw.) Moore, is unknown from the Galapagos Islands.

Hemitelia R. Br.

H. aff. Subcaesia Sodiro, Cr. Vasc. Quit. 522 (1893). H. multiflora sensu Stewart (1), 20; not (Sm.) R. Br.—Albemarle Isl.: Stewart. Chatham Isl.: Stewart. James Isl.: Stewart.

Stewart's collections (nos. 895-7) are quite different from true *H. multiflora* (illustrated by Maxon, Bull. Torrey Club **38**: 545-550, pl. 35 (1911)). They have the general appearance of *Cyathea purpurea* of the West Indies. The large indusium is half-circular at the base, but cucullate and covering the entire sorus. The entire lower surface of the pinnules—at least in the younger stages—is covered by large appressed, flattened, ashy-gray scales, usually with hardened filamentous appendages. These are intermingled with smaller trichome-like scales and rigid short-jointed hairs.

HISTIOPTERIS Agardh

*H. INCISA (Thunb.) J. Sm. Hist. Fil. 295 (1875); Stewart (1), 21. Pteris incisa Thunb. Prod. Fl. Cap. 171 (1800); Rob. (1), 114.—The only specimen which I have seen is the collection by Capt. Wood (Kew), cited by Hooker, Sp. Fil. 2: 230 (1858). It consists of typical material with soft rounded pinnae, not yet in the fruiting stage. Stewart's misidentified collections (Cal) are Pteridium arachnoideum (no. 997) and Pteris biaurita (nos. 998, 999, 1000).

HYMENOPHYLLUM Sm.

H. CILIATUM Sw. in Schrad. Journ. 1800²: 100 (1801). H. hirsutum sensu Stewart (1), 21; not (L.) Sw.—Chatham Isl.: Wreck Bay, Stewart no. 898 (US).

HYPOLEPIS Bernh.

H. REPENS (L.) Presl, Tent. Pterid. 162 (1836); Rob. (1), 109; Stewart (1), 21. Lonchitis repens L. Sp. Pl. 1078 (1753).—Indefatigable Isl.: Academy Bay, common in clearings, 800 ft., Svenson no. 109; south slope of mountain, 1625 ft., Svenson no. 131; 4-6 ft. high, forming much of the fern vegetation at 2000 ft., Svenson no. 147. Galapagos Ids.: Capt. Wood (Kew), a poor specimen, cited by Hooker, Sp. Fil. 2: 64 (1858).

NEPHROLEPIS Schott

N. BISERRATA (Sw.) Schott, Gen. Fil. ad t.3 (1834); Stewart (1), 21. Nephrolepis acuta Presl, Tent. Pterid. 79 (1836); Rob. (1), 110.—Abingdon Isl.: 1650 ft. Stewart. Albemarle Isl.: Villamil, near the shore, Stewart no. 921 (G). Bindloe Isl.: common in the interior, Stewart no. 918 (G); Snodgrass & Heller no. 779 (G). Wenman Isl.: in lava coverns and on cliffs, Stewart no. 919.

N. PECTINATA (Willd.) Schott, Gen. Fil. ad t.3 (1834); Rob. (1), 110; Stewart (1), 22. Nephrodium pectinatum Presl; Hook.f. Trans. Linn. Soc. 20: 170 (1847).—Abingdon Isl.: 1950 ft., Stewart. Albemarle Isl.: Villamil, 1350 ft., Stewart. Chatham Isl.: Wreck Bay, 1800 ft., 2100 ft., Stewart no. 926 (G); southwest end, Baur no. 357 (G). Duncan Isl.: 1300 ft., Stewart. Indefatigable Isl.: Academy Bay, above 500 ft., Stewart; Academy Bay, an abundant epiphyte at 1100–1600 ft., Svenson no. 127; forming fern banks on the ground at 2000 ft., Svenson no. 222. James Isl.: James Bay, lava crevices at 2150–2850 ft., Stewart no. 923 (G); Darwin (represented by two sheets), (as Nephrodium pectinatum).

NOTHOLAENA R. Br.

Notholaena galapagensis Weatherby & Svenson, sp. nov. (Pl. 9, fig. 2). Rhizoma obliquum, breve repens, (2–4 cm. longum, 3 mm. diametro) paleis rigidis, reticulatis castaneis vel mature brunnescenti-fuscis lanceolatis vel lanceolato-ovatis (4–5 mm. longis, 1.3 mm. latis) haud denticulatis acuminatis concoloribus margine pallidiore angustissimo saepe fere obsoleto excepto vestitum; folia subcoriacea, supra glabra, infra pulvere ceracea, subsulphurea obtecta; petiolus 4–12 cm. longus, brunneosubnitidus, ad basim paleis nonnullis divaricatis, semi-deciduis, brunnescenti-fuscis concoloribus reticulatis, attenuatis (3–3.5 mm. longis, 1 mm. latis) obsitus; lamina 5–11 cm. longa, 3–5 cm. lata ovato-oblonga bipinnatifida, deorsum in segmento primario tripinnatisecta; segmenta primaria opposita vel subopposita, infima 3 cm. distantia (3–4 cm. longa), breviter petiolata, anguste deltoideo-ovata, superiora sessilia oblonga, apice attenuata obtusa, pinnatipartita; laciniae vel segmenta secundaria coadunata oblonga obtusa, latere inferiore segmentorum infimorum non

auctis, omnia margine levissime crenulata; nervi immersi; sori nigricantes oligocarpi, frequenter monocarpi, sporangio maturo magno (330 μ diametro), massae ceraceae immersi, lineam intramarginalem efformantes, basi lobulis non scariosis cincti. N. candidae affinis, a qua inter aliis, squamis concoloribus segmentis infimis aequilateralibus stipite brunneo differt. N. candida (M. & G.) Hook. var. lutea (Cav.) Hook. Sp. Fil. 5: 111 (1864) as to plant, not as to name-bringing synonym. Pteris lutea sensu Hook.f. Trans. Linn. Soc. 20: 168 (1847), not Cav. Descr. 267 (1802). N. sulphurea sensu Rob., Proc. Am. Acad. 38: 111 (1902); Stewart, Proc. Cal. Acad. Sci. ser. 4, 1: 22 (1911); not J. Sm. in Seem. Bot. Voy. Herald 233 (1854), based on Pteris sulfurea Cav. Descr. 269 (1802).—Albemarle Isl.: Snodgrass & Heller; Stewart. Indefatigable Isl.: Academy Bay, dry lava cliffs of escarpment at 100 ft., Svenson no. 79. James Isl.: Scouler (Kew); Stewart. Narborough Isl.: Stewart. Galapagos Ids.: Cuming no. 110 (Kew). As the type, Snodgrass & Heller no. 23 (Gray Herbarium) from Iguana Cove, Albemarle Island is designated.

Historically Hooker's (1847) identification of Scouler's and Cuming's plants as *Pteris lutea* rested only on Sprengel's brief description (Syst. 4:74 (1827)), in turn based on Cavanilles' description of a Mexican plant. Later Hooker (1864) treated the Galapagos plants as *Notholaena candida* without ascribing them to any definite variety, although the var. *lutea* in Hooker's somewhat confused account was made to include collections from Peru by Mathews and by Gillies. By Hooker & Baker (Syn. Fil. 373 (1868)), *N. candida* was further merged into the synonymy of *N. sulphurea* J. Sm., quite evidently the source of Dr. Robinson's employment of the latter name, which applies to a tripartite Mexican species.

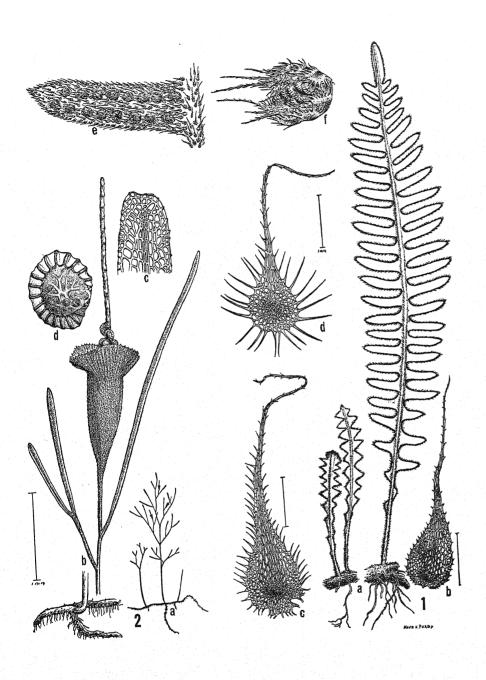
In reviewing the identity of *Pteris aurantiaca* and *P. lutea*, Christensen (Arkiv. f. Bot. 9²: 42 (1900) and Dansk Bot. Arkiv. 60, no. 3: 22 (1937)) finds that both are the same species i.e. *Cheilanthes lutea* (Cav.) Moore.

The yellow cera of the Galapagos plant consists of small stalked crateriform extrusions which are often linked up in the mature frond into a cobwebby mass. The sori are partially (sometimes wholly) covered by the revolute margin of the young frond; the mature sori are borne just within the revolute margin, only one sporangium in each sorus usually maturing. The sessile hemispheric sporangia average 330μ in width; the smooth dusky olivaceous spores are about the size of the spores of *Pellaea atropurpurea*.

Explanation of Plate 8

Fig. 1. Polypodium lepidopteris (no. 231): a, habit $\times \frac{1}{2}$. b, scale from rhizome. c, scale from stipe. d, scale from lower surface of pinna. e, lower surface of pinna ($\times 2$). f, sorus, with adjacent scales.

Fig. 2. Trichomanes cocos (no. 349): a, habit $\times \frac{1}{2}$. b, details of rhizome and tip of frond. c, apex of segment. d, sporangium.



SVENSON: PTERIDOPHYTA

The margin of the frond is unmodified, the cerate to somewhat glandular edge being without scales or hyaline tissue. Veins show only in the basal lobule of each segment, and as the midrib of the segment. The entire situation is much the same as in E. J. Palmer no. 13608 (Notholaena candida) except for a tendency in the latter toward transformation of the frond margin, thinner frond with obvious venation, and cerous trichomes (of different color than in N. galapagensis) on the upper surface of the frond as well as on the lower surface. N. candida also differs in having more approximate pinnae with linear-lanceolate divisions. The Galapagos plant is obviously not the same species; the difference is clear in illustrations by Martens & Galeotti and by Eaton.

Of the six species included by Mettenius (1859) in the group with fronds cerate on the lower surface, only Cheilanthes affinis, C. candida, and C. monosticha have lanceolate fronds. C. monosticha Mett. (based on Ceropteris monosticha Fée, Mém. 7: 44, t. 22, fig. 2 (1857) came from Mexico and was known to Mettenius only from Fée's description and plate. By Mettenius it was considered as scarcely distinct from C. candida except in the presence of a yellow instead of a white cera.

Hooker & Baker (l.c.) included several of Mettenius' species within Notholaena sulphurea J. Sm., with the following notation (p. 374): "We include here four species of Mettenius. His C. Borsigiana, Reichb., has the pinnae very close, and the lower pair much larger than the others. within the powder bright-yellow. From this C. cretacea seems to differ only by its white powder, and there are various intermediate stages. In C. candida and monosticha the pinnae are not so close and less unequal, the powder being white in the first and yellowish in the latter."

The type of C. Borsigiana, the only one of the group based on South American material (Peru), has been recently examined by Mr. Weatherby and found to be no more than a form of Notholaena sulphurea.

PITYROGRAMMA Link

P. CALOMELANOS (L.) Link, Handb. Gew. 3: 20 (1833); Maxon, Contr.

Explanation of Plate 9

Fig. 1. Polypodium aff. Steirolepis (no. 93): a, habit $\times \frac{1}{2}$. b, scale from rhizome with (c) detail of lower portion. d, scale from stipe. e, sporangium.

Fig. 2. Notholaena galapagensis (no. 79): a, habit $\times \frac{1}{2}$. b, scale from rhizome. c, scale from stipe. d, sterile pinnule, showing venation. e, fertile pinnule, showing margin. f, sporangium, g, cera (much enlarged).

Fig. 3. DIPLAZIUM aff. SUBOBTUSUM (no. 132): a, portion of frond, $\times \frac{1}{2}$. b, detail of

lower part of a pinnule.



SVENSON: PTERIDOPHYTA

U. S. Nat. Herb. 17: 173 (1913). Ceropteris tartarea (Cav.) Link; Stewart (1), 16. Gymnogramma tartarea Desv. Berl. Mag. 5: 305 (1811); Rob. (1), 109.—Albemarle Isl.: Snodgrass & Heller; Stewart. BINDLOE Isl.: Stewart. Charles Isl.: Stewart. Charles Isl.: Chiercha; Stewart; Baur. Duncan Isl.: Stewart. Indefatigable Isl.: Academy Bay, locally in moist places among boulders, 1000–1100 ft., Svenson no. 218. James Isl.: Stewart.

P. Presliana Domin, var. Aurata Dom. Publ. Fac. Sci. Univ. Charles 886: 19, t.1 (1929). Gymnogramme tartarea var. aurata Moore, Gard. Chron. 493 (1870).—BINDLOE ISL.: Snodgrass & Heller no. 778 (G), a juvenile specimen with flabellate fronds which are yellow-powdered on the under surface.

POLYPODIUM L.

P. ANGUSTIFOLIUM Sw. Prod. 130 (1788); Rob. (1), 111; Stewart (1), 23. Marginaria ensifolia Presl; Hook.f. Trans. Linn. Soc. 20: 167 (1847).— JAMES ISL.: Darwin; James Bay, 2100 ft., Stewart no. 935. Darwin's specimen at Cambridge is very doubtfully this species, and most probably P. lanceolatum.

P. AUREUM L. Sp. Pl. 1087 (1753); Rob. (1), 111; Stewart (1), 23. Pleopeltis aurea Hook.f. Trans. Linn. Soc. 20: 167 (1847).—ALBEMARLE ISL.: Stewart. Duncan Isl.: Stewart. James Isl.: Stewart. Galapagos Ids.: Darwin; Capt. Wood. The monstrous specimen collected by Darwin, which Hooker (l.c.) mentions, is clearly this species. I was unable to find Capt. Wood's specimen at Kew.

P. CRASSIFOLIUM L. Sp. Pl. 1083 (1753); Rob. (1), 112. Stewart (1), 23.—Albemarle Isl.: Tagus Cove, Stewart no. 941 (perhaps P. Phylli-

tidis). GALAPAGOS IDS.: Capt. Wood (two sheets at Kew).

P. LANCEOLATUM L. Sp. Pl. 1082 (1753); Rob. (1), 112; Stewart (1), 23. Pleopeltis macrocarpa Kaul.f.; Hook.f., Trans. Linn. Soc. 20: 167 (1847). Pleopeltis lepidota Willd.; Hook.f. (l.c.).—Albemarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Darwin; Andersson; Stewart. Duncan Isl.: Stewart. Indefatigable Isl.: Stewart; Academy Bay, epiphyte, 400 ft., Svenson no. 56; 2000 ft., Svenson no. 213. James Isl.: Darwin. Darwin's plant from James Island has wide fronds (3.3 cm.) identical with no. 213; his collection from Charles Island has fronds only 1 cm. wide.

P. LEPIDOPTERIS (Langsd. & Fisch.) Kze. Linnaea 13: 132 (1836), sensu lat.; Hook. Sp. Fil. 4: 212 (1862); Rob. (1), 112; Stewart (1), 23. Albemarle Isl.: Stewart. Duncan Isl.: Stewart. Indefatigable Isl.: Stewart; Academy Bay, abundant epiphyte at 500 ft., Svenson no. 231

(Pl. 8, fig. 1). JAMES ISL.: Stewart. GALAPAGOS IDS.: Capt. Wood (2 sheets, the glistening, almost micaceous texture of the under surface, and the isolated deep brown scales of the rachis being especially noticeable).

Stewart's nos. 452, 954, 955, and 956 are this species.

*P. LORICEUM L. Sp. Pl. 1086 (1753); Rob. (1), 112; Stewart (1), 24. Moore, Ind. Fil. 392 (1862).—Galapagos Ids.: Capt. Wood. This collection at Kew (apparently the basis of Moore's citation) is identical with specimens collected by Seemann at the Bay of Cupica in 1848. Only a portion of the blade is present. This exceeds 40 cm. in length and 14 cm. across, with the acute pinnae up to 1.5 cm. wide, and the sori in several (often 4) rows.

P. PECTINATUM L. Sp. Pl. 1085 (1753); Rob. (1), 113; Stewart (1), 24. P. paradiseae Langsd. & Fisch. Ic. Fil. 11, t. 11 (1810-1818); Hook.f. Trans. Linn. Soc. 20: 165 (1847).—Abingdon Isl.: Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Andersson; Stewart. Charlem Isl.: Chiercha; Baur; Stewart. Indefatigable Isl.: Stewart; Academy Bay, common on ground in underbrush 350-600 ft., Svenson no. 74. James Isl.: Darwin; Stewart.

*P. PERCUSSUM Cav. Descr. 243 (1802); Hook. Fil. Exot. t. 59 & Sp. Fil. 5: 56 (1864); Rob. (1), 113; Stewart (1), 24.—Galapagos Ids.: Capt.

Wood (Kew). The frond is 3 cm. in diameter with prominent sori.

P. PHYLLITIDIS L. Sp. Pl. 1083 (1753); Rob. (1), 113; Stewart (1), 24. Campyloneuron Phyllitidis Presl; Hook.f. Trans. Linn. Soc. 20: 167 (1847). —INDEFATIGABLE ISL.: Academy Bay, 550 ft., Stewart no. 940 (Cal) (2 sheets, as P. crassifolium) (no. 941 not seen); Academy Bay, in shaded undergrowth near entrance to Plantation Fortuna, 700 ft., Svenson no. 114, and not uncommon to 1000 ft. James Isl.: Darwin; above 1500 ft., Stewart no. 969. Also probably represented by "large sword ferns" (Stewart l.c.) on Abingdon Island.

P. POLYPODIOIDES (L.) Watt, Canad. Nat. II. 13: 158 (1867). Polypodium incanum Sw. Prod. 131 (1788); Hook.f. Sp. Fil. 4: 209 (1862); Rob. (1), 112 (only as to Capt. Wood's collection).—Albemarle Isl.: Villamil, common on the trunks of trees at 600 ft., Stewart no. 944. Indefatigable Isl.: Academy Bay, on the trunks and branches of trees above 425 ft., Stewart no. 942; southeast side, common on tree trunks at 625 ft., Stewart no. 943; Rorud no. 259. Chatham Isl.: Capt. Wood, a small specimen 6-7 cm. high, scales short and somewhat rufous.

P. aff. STEIROLEPIS C. Chr. Amer. Fern Journ. 7: 33 (1917). P. thyssanolepis sensu Stewart (1), 26; not A. Br. ex Klotzsch.—Albemarle Isl.: Villamil, abundant at 600 ft., on trees at 1300 ft., Stewart nos. 989 (Cal), 990 (Cal). Indefatigable Isl.: Academy Bay, epiphyte at 2000

ft., Svenson no. 93 (Pl. 9, fig. 1). James Isl.: occasional on trunks of trees, 2750 ft., Stewart no. 991 (Cal).

Dr. Maxon has very kindly furnished the following comments on the specimens of my collection (no. 93):

The venation . . . is anomalous, being imperfectly goniophlebioid, with an occasional indication of phlebodioid venation. Plants having the general aspect of no. 93 have commonly been referred to *P. leucosticton* Kunze, but mistakenly so, inasmuch as that species has winged stipes and free venation. Your plant is obviously related to *P. steirolepis* C. Chr., but that very critical species, as shown by several recent specimens, has definitely phlebodioid venation.

Another species that must be taken into account in this connection is *P. Fraseri* Mett., described from Ecuador. I have not seen the type of this or any authentic material; but I have removed from our cover of *P. leucosticton* a good many specimens from Colombia, Peru, and Ecuador which I now refer here tentatively, assuming that Mettenius's description was drawn from an under-sized specimen. In the character of the rhizome scales and in all real diagnostic features these plants agree with the description of *P. Fraseri*, and I think I am correct in referring them to that species, which in its rhizome scales (but not in several other characters) shows a very definite affinity to *P. leucosticton*. Your no. 93 can not be referred here nearly so well as to *P. steirolepis*, and my best judgment would be that you refer it, for the present, tentatively to *P. steirolepis*. It bears a very close *general* appearance to plants of that species and differs mainly in its less complicated venation. Possibly no. 93 represents a new species, but more probably it can be connected with typical *P. steirolepis* by plants showing intermediate stages of venation, when sufficient new material has been collected.

P. TRIDENS Kze. Farnkr. 1: t. 13, fig. 1 (1840); Hook. Sp. Fil. 4: 210 (1862). P. squamatum sensu Rob. (1), 113; Stewart (1), 25; not L. Marginaria incana Hook.f. Trans. Linn. Soc. 20: 166 (1847); Rob. (1), 113 (in part).—Abingdon Isl.: Snodgrass & Heller; Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Bindloe Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Darwin; Andersson; Capt. Markham (Kew); Lee; Baur; Stewart. Chatham Isl.: Capt. Wood; Snodgrass & Heller; Baur; Stewart. Duncan Isl.: Baur; Snodgrass & Heller; Stewart. Indefatigable Isl.: Stewart; Rorud; terrestrial in thickets, half hidden by bushes, 500 ft., Svenson no. 73 (occasional at 250 ft., common at 450–600 ft.). James Isl.: Stewart. Jervis Isl.: Stewart. Narborough Isl.: Stewart. Galapagos Ids.: Cuming no. 112.

Marginaria incana, from the Galapagos Islands, was known by Hooker as "var. frondibus plerumque pinnatis, pinnis inferioribus 2-3 furcatis." Darwin's specimens are P. tridens, as are also, without serious question, those of Macrae (specimens not seen). The collection by Capt. Markham has one pinna with five segments; otherwise it is like Cuming's type collection.

POLYSTICHUM Roth

P. aff. PYCNOLEPIS Moore, Ind. 92 (1858). *P. aculeatum* sensu Stewart (1), 26; not (L.) Schott. Albemarle Isl.: Villamil, 3150 ft., *Stewart* no. 802 (Cal).

P. ADIANTIFORME (Forst.) J. Sm. Hist. Fil. 220 (1875); Stewart (1), 26. Aspidium coriaceum Sw. in Schrad. Journ. Bot. 1800²: 40 (1801); Rob. (1), 106; Polystichum coriaceum Presl; Hook.f. Trans. Linn. Soc. 20: 171 (1847).—Albemarle Isl.: Villamil, 3150 ft., Stewart no. 803 (Cal.) James Isl.: Darwin. Darwin's two specimens agree well with other South American collections.

PTERIDIUM Gled.

P. ARACHNOIDEUM (Kaulf.) Maxon, Journ. Wash. Acad. Sci. 14: 89 (1924). P. aquilina var. esculenta Hook.f. Fl. N. Zeal. 2: 25 (1855) and Hook. Sp. Fil. 2: 198 (1858); Rob. (1), 114; Stewart (1), 26.—Abingdon Isl.: forms extensive brakes on the south side of the island above 1600 ft., Stewart no. 992; occasional around 1950 ft., Stewart no. 997 (Cal.) (as Histiopteris incisa). Albemarle Isl.: Snodgrass & Heller; Stewart. Chatham Isl.: Baur; Stewart. Indefatigable Isl.: Academy Bay, forming thickets at 2000 ft., Svenson no. 212. Galapagos Ids.: Capt. Wood, the collection closely resembling no. 212.

PTERIS L.

*P. PROPINQUA var. Cumingiana Ag. Sp. Gen. Pterid. 65. (1839); Hook. Sp. Fil. 2: 223 (1858); Rob. (1), 115; Stewart (1), 26.—Chatham Isl.: Capt. Wood. The specimen at Kew, labeled "Chatham I." closely resembles Spruce no.5708 from Guayaquil. In addition to the citation from the Galapagos Islands, var. Cumingiana is also mentioned by Hooker (l.c.) from Mexico to Venezuela and from the West Indies, and he further notes: "Of this Pt. propinqua I may observe, it will be difficult to distinguish it from some states of Pt. aculeata, Sw.; and the var. Cumingiana with its more rigid fronds, shorter more falcate, and often more mucronate segments, is, I fear, identical with P. apicalis of Liebmann." Capt. Wood's specimen apparently is the same as a fragment of the type collection at the U. S. National Herbarium.

P. QUADRIAURITA Retz. Obs. 6: 38 (1791). Histiopteris incisa sensu Stewart (1), 21; not (Thbg.) J. Sm.—Albemarle Isl.: Stewart nos. 998 & 1000 (Cal) (as H. incisa).—Indefatigable Isl.: Academy Bay, occasional in shaded underbrush, 800 ft., Svenson no. 100. James Isl.: James Bay, Stewart no. 999 (Cal) (as H. incisa). By Christensen (Index Filicum 593 (1906)), this species is included under P. biaurita L.

TECTARIA Cav.

T. MARTINICENSIS (Spr.) Copel. Phil. Journ. Sci. 2c: 410 (1907). Aspidium martinicense Spr. Anleit. 3: 133 (1804); Stewart (1), 13. Nephrodium macrophyllum Bak. Syn. Fil. 300 (1874); Rob. (1), 110.—Albemarle Isl.: Stewart no. 902 (Cal). Chatham Isl.: Capt. Wood. James Isl.: Stewart no. 903. Captain Wood's specimens at Kew are the same as Stewart's no. 903.

TRACHYPTERIS André

T. PINNATA (Hook.f.) C. Chr. Ind. 634 (1906); Stewart (1), 27. Hemionitis pinnata Hook.f. Trans. Linn. Soc. 20: 167 (1847). Acrostichum aureo-nitens Hook.f. Ic. Pl. 10: t. 933 (1854); Rob. (1) 104.—Abingdon Isl.: Stewart. Albemarle Isl.: Snodgrass & Heller; Stewart. Charles Isl.: Darwin; Andersson; Lee; Baur; Stewart. Chatham Isl.: Capt. Wood; Stewart. Indefatigable Isl.: Stewart; Rorud; Academy Bay, abundant on exposed rocks, 100–300 ft. and on lava ledges in damp shaded woods, 400 ft., Svenson no. 226. James Isl.: Stewart. Narborough Isl.: Snodgrass & Heller. Galapagos Ids.: Capt. Wood; Capt. Markham.

This is perhaps the most spectacular fern of the Galapagos Islands. It can maintain itself on bare lava ledges, though fruiting specimens, in my experience, are confined to comparatively damp habitats. In addition, the species is known from the mainland, being represented by the following examples which I have examined; Ecuador: Andibus merid. circa 3800 m., E. André no. 4699 (Kew). Peru: Colpapampa, 9000 ft., Bues no. 1339 (US); Toronton, 2000–2800 m., Herrera no. 1334 (US); Santa Ana, 900 m., Cook & Gilbert no. 1480 (US) & no. 1563 (US). Bolivia: Asilla, 3500 ft., R. S. Williams no. 1177 (NY); Espia, head of Bopi River, 3500 ft., Rusby no. 305 (B, NY).

The Brazilian plant, **T. Gilliana** (Baker) n. comb. (Acrostichum Gillianum Baker, Journ. Bot. 310 (1882)) from Arasenahy, Minas Geraes (Glaziou no. 1334) and "Catingawald bei Tambury," Bahia, Ule no. 7070 (Kew), does not apparently represent the same species as the Bolivian-Ecuadorian material, since in addition to the narrowly-trifid fertile pinnae the scales of the rachis are decidedly opaque as contrasted with the translucent scales of the plant from western South America. Furthermore, the fronds of Glaziou's collection are narrower, and hairy above as well as below. I can find no restriction of sporangia to the veins in dissecting the Galapagos specimens; the sporangia are borne over the entire frond surface. The genus would therefore seem to be close to Elaphoglossum (cf. however, Christensen, Dansk. Bot. Arkiv. 7: 110 (1932)).

TRICHOMANES L.

T. Krausii Hook. & Grev. Ic. Fil. 2: t.149 (1831). Hymenophyllum Polynthos sensu Stewart (1), 21; not Sw. Trichomanes pusillum sensu Stewart (1), 27.; not Sw.—Duncan Isl.: in dense tufts on the southeast side of rocks at 1300 ft., Stewart no. 899 (Cal) (as H. polyanthos). INDE-FATIGABLE ISL.: Academy Bay, on dripping rocks, south slope of mountain, 1500 ft., Svenson no. 220. James Isl.: James Bay, common on moist tufa walls at 2050 ft., Stewart no. 1013 (reported as no. 1012) (Cal) (as T. pusillum).

SALVINIACEAE Azolla Lam.

A. FILICULOIDES Lam. Encyc. 1: 343 (1783). A. caroliniana sensu Rob. (1), 115; Stewart (1), 27; not Willd.—CHARLES ISL.: Andersson; Stewart no. 3441 (Cal). CHATHAM ISL.: Stewart no. 3442 (Cal). INDEFATIGABLE Isl.: abundant on the surface of pools west of Academy Bay, Svenson no. 86.

Although I have not seen Andersson's collection (reported as A. caroliniana) I have little hesitation in placing it under A. filiculoides, coming as it did from the same place as Stewart's collection.

> EOUISETACEAE EQUISETUM L.

E. BOGOTENSE HBK. Nov. Gen. & Sp. 1: 42 (1815); Stewart (1), 28.— ALBEMARLE ISL.: Stewart.

LYCOPODIACEAE LYCOPODIUM L.

L. CERNUUM L. Sp. Pl. 1103 (1753).—INDEFATIGABLE ISL.: Rorud.

L. CLAVATUM L. Sp. Pl. 1101 (1753); Rob. (1), 115; Stewart (1), 28.— CHATHAM ISL.: Baur; Stewart. INDEFATIGABLE ISL.: Rorud; Academy Bay, abundant at 2000 ft., Svenson no. 207. JAMES ISL.: Stewart.

L. COMPLANATUM L. Sp. Pl. 1104 (1753); Stewart (1), 28.—Albe-

MARLE ISL.: Stewart. INDEFATIGABLE ISL.: Rorud.

L. DICHOTOMUM Jacq. Enum. Vindob. 314 (1762); Rob. (1), 115; Stewart (1), 28.—Albermarle Isl.: Stewart. Indefatigable Isl.: Stewart; Academy Bay, epiphyte, 400 ft. alt., Svenson no. 400.

L. REFLEXUM Lam. Encyc. 4: 653 (1789); Stewart (1), 28.— ALBE-

MARLE ISL.: Stewart.

L. TAXIFOLIUM Sw. Prod. 138 (1788).—CHARLES ISL.: Stewart. INDE-FATIGABLE ISL.: Rorud; Academy Bay, epiphyte on Xanthoxylon trees at 1100-2000 ft., Svenson no. 208. James Isl.: Stewart.

PSILOTACEAE

PSILOTUM Sw.

P. NUDUM (L.) Griseb. Abh. Ges. Wiss. Goettingen 7: 278 (1857). *P. triquetrum* Sw. in Schrad. Journ. Bot. 1800²: 109 (1801); Riley, Kew Bull. 1925: 231 (1925).—James Isl.: *Riley*.

COCOS ISLAND

(Only the pteridophytes collected by the Astor Expedition are included in this list.)

ASPLENIUM L.

A. Macraei Hook. & Grev. Ic. Fil. t.217 (1831).—Wafer Bay, abundant on cliff walls at 700 ft., Svenson no. 339.

This material is exactly like the type from Hawaii collected by Macrae (Kew) and the same as the collection at Kew of A. dubium (Brackenridge no. 55, consisting of rather poor specimens) from the Fiji Islands (?). The specimens previously collected on Cocos Island under the name A. cristatum (Stewart no. 228) and as A. rhizophyllum (Snodgrass & Heller no. 954) are A. Macraei.

DENNSTAEDTIA Bernh.

D. GLOBULIFERA (Poir.) Hieron, in Engler, Bot. Jahr. 34: 455 (1904).—Wafer Bay, abundant from near sea level to above 1000 ft., Svenson no. 343.

Danaea J. E. Smith

D. NODOSA (L.) Sm. Mém. Ac. Turin 5:420 t.9, fig. 11 (1793).—Wafer Bay, abundant in alluvial soil along brook, *Svenson* no. 328 (Pl. 10). I am of the opinion that the "small palms" in Stewart's illustration, pl. 33 (op. cit.) are this species.

DICRANOPTERIS Bernh.

D. PECTINATA (Willd.) Underw. Bull. Torrey Club **34**: 260 (1907). *Mertensia pectinata* Willd. Sv. Vet. Akad. Handl. ser. 2, **25**: 168 (1804).—Wafer Bay, covering banks of stream at 150 ft., *Svenson* no. 332.

ELAPHOGLOSSUM Schott

E. APODUM (Klf.) Schott, Gen. Fil. ad t.14 (1834). Acrostichum

Explanation of Plate 10

Pl. 10. Danaea nodosa (no. 328): a, tip of frond $\times \frac{1}{2}$. b, portion of fertile pinna (lower surface) with enlarged scales (c) and as seen in cross section (d). e-h, details of sporangia and spores.



SVENSON: PTERIDOPHYTA

apodum Kaulf. Enum. 59 (1824).—Wafer Bay, epiphyte at 1000 ft., Svenson no. 403.

E. CRINITUM (L.) Christ, Mon. 112, fig. 53 (1899). Acrostichum crinitum L. Sp. Pl. 1068 (1753).—Wafer Bay, epiphyte on trunks of tree ferns, 1000 ft., Svenson no. 402.

HYMENOPHYLLUM J. E. Smith

H. POLYANTHOS Sw. in Schrad. Journ. 1800²: 102 (1801).—Wafer Bay, on mossy tree trunks at 1000 ft., Svenson no. 345.

HYPOLEPIS Bernh.

H. aff. viscosa (Karst.) Mett. Ann. Sc. Nat. V. 2: 238 (1864) (nomen); Karst. Fl. Col. 2: 89, t.145, 146 (1869).—Wafer Bay, along brook up to 800 ft., *Svenson* no. 341.

LINDSAEA Dryand

L. MONTANA Fée, Mém. Foug, 11: 17, t.6, fig. 2 (1866).—Chatham Bay, along brook near sea level, Svenson no. 433.

NEPHROLEPIS Schott

N. BISERRATA (Sw.) Schott, Gen. Fil. ad pl. 3 (1834). Aspidium biserratum Sw. in Schrad. Journ. Bot. 1800²: 32 (1801).—Wafer Bay, banks of the stream at 150 ft., Svenson no. 350.

OLEANDRA Cav.

O. ARTICULATA (Sw.) Presl, Tent. Pter. 78 (1836). Aspidium articulatum Sw. in Schrad. Journ. Bot. 1800²: 30 (1801).—Chatham Bay: an abundant epiphyte, Svenson no. 312.

POLYBOTRYA Humb. & Bonpl.

POLYBOTRYA CERVINA (L.) Klf. Enum. 55 (1824). Osmunda cervina L. Sp. Pl. 1065 (1753).—Wafer Bay, on ground along brook, 200-1000 ft., Svenson no. 342.

POLYBOTRYA SP. Wafer Bay, in rock crevices and on the ground 800 ft., Svenson no. 340 (young plants).

POLYPODIUM L.

P. ASTROLEPIS Liebm. Dansk. Vid. Selsk. Skrift. V. 1: 185 (1849); Weatherby, Contrib. Gray Herb. no. 65: 6 (1922).—Wafer Bay, a common epiphyte along brook, *Svenson* no. 321.

P. LATUM (Moore) Sodiro, Crypt. Vasc. Quit. 371 (1893). Camplyoneurum latum Moore, Ind. Fil. 225 (1861).—Chatham Bay, abundant on hillsides and along streams, Svenson no. 311.

SACCOLOMA Kaulf.

S. ELEGANS Kaulf. Berl. Jahrb. Pharm. 1820: 51 (1820).—Wafer Bay, rather common on ground in shady places, 300 ft., Svenson no. 336.

TRICHOMANES L.

T. Cocos Christ, Bull. Boiss. II. 4: 943 (1904).—Wafer Bay, abundant on trunks of tree ferns at app. 1000 ft., Svenson no. 349 (Pl. 8, fig. 2).

This endemic species, closely related to *T. capillaceum* L., is described as having the pinnae more sprawling so that the frond becomes flabellate at its periphery. The segments are said to be thicker and somewhat dilated at the ends, and the receptacles less open; the color of the plant, in general, is darker.

T. ELEGANS Rich. Act. Soc. Hist. Nat. Paris 1: 114 (1792).—Chatham Bay, dark moist places beneath ledges; fronds bluish-green. Common to 1000 ft., and probably above, *Svenson* no. 313, alt., 50 ft.

T. GALEOTTII Fourn. Bull. Soc. Fr. 15. 144, 147 (1868).—Wafer Bay,

epiphyte with translucent fronds, at 800 ft., Svenson no. 407.

T. Hookeri Presl., Abh. Boehm. Ges. Wiss. v. 3. 108 (1843).—Wafer Bay, on a decayed stump at 800 ft. but not otherwise noted. Svenson no. 344.

T. RADICANS Sw. in Schrad. Jour. 1800: 97 (1801).—Chatham Bay, abundantly climbing on damp rocks and tree trunks, but only one clump seen in fruiting stage, 800 ft., Svenson no. 328.

VITTARIA J. E. Smith

V. LINEATA (L.) Sm., Mém. Acad. Turin 5: 413, pl. 9, fig. 5 (1793). Wafer Bay, epiphyte near sea level, *Svenson* no. 330.

LYCOPODIUM L.

L. PITTIERI Christ, Bull. Soc. Bot. Genève, ser. 2, 1: 236 (1909). Wafer Bay, a fairly common epiphyte, the branches hanging vertically, *Svenson* no. 324. (det. W. R. Maxon).

SELAGINELLACEAE

SELAGINELLA Beauv.

S. HORIZONTALIS (Presl) Spring, Mon. Lycop. pt. 2, 264 (1848). Wafer Bay, beneath trees near beach, *Svenson* no. 320. (det. A. H. G. Alston).

BROOKLYN BOTANIC GARDEN, BROOKLYN, NEW YORK



INDEX TO AMERICAN BOTANICAL LITERATURE 1935-1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the

word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

- Adams, J. Some marine algae from Anticosti Island and the Gaspé Peninsula. Canadian Field Nat. 52: 10, 11. 6 Ja 1938.
- Albaum, H. G. Normal growth regeneration, and adventitious outgrowth formation in fern prothallia. Am. Jour. Bot. 25: 37-44. f. 1-12. Ja 1938.
- Anderson, E. G. Induced chromosomal alterations in maize. In Duggar, B. M. Biological effects of radiation. 1297-1310. 1936.
- Arthur, J. M. Plant growth in continuous illumination. In Duggar, B. M. Biological effects of radiation. 715-725. 1936.
- Arthur, J. M. Some infra-red effects on green plants. In Duggar, B. M. Biological effects of radiation. 841-852. f. 1, 2. 1936.
- Arthur, J. M. Radiation and anthocyanin pigments. In Duggar, B. M. Biological effects of radiation. 1109-1118. 1936.
- Avery, G. S., Burkholer, P. R., & Creighton, H. B. Growth hormone in terminal shoots of Nicotiana in relation to light. Am. Jour. Bot. 24: 666-673. f. 1-6. D 1937.
- Avery, G. S. & others. Darwin and early discoveries in connection with plant hormones. Science 87: 66. 21 Ja 1938.
- Azevedo-Penna, L. Floração da Primavera. Rodriguesia 26: 247-252. 1936.
- Contribuição para o conhecimento dos Azevedo, F. D. de. Rodriguesia 26: microorganismos dos sólos Brasileiros. 203-207. 1936.
- Beal, J. M. Cytological studies in the genus Phoenix. Bot. Gaz. 99: 400-407. f. 1-15. D 1937.
- Bell, H. P. & MacFarlane, C. Some marine algae from Labrador, Hudson Bay, and Arctic Canada. Canadian Field Nat. 52:9, 10. 6 Ja 1938.
- Bell, H. P. The origin of russeting in the golden russet apple. Canadian Jour. Res. 15: 560-566. f. 1-15. D 1937.

- Biggs, R. Cultural studies in the Thelephoraceae and related fungi. Mycologia 30: 64-78. f. 1-20. Ja-F 1938.
- Blake, C. H. Wolffiella floridana in Massachusetts. Rhodora 40: 76. F 1938.
- Blakeslee, A. F. & Avery, A. G. Methods of inducing doubling of chromosomes in plants. Jour. Heredity 28: 393-412. f. 1-12. frontisp. D 1937.
- Bonner, D. M. Activity of the potassium salt of indole (3) acetic acid in the *Avena* test. Bot. Gaz. 99: 408-411. D 1937.
- Bramble, W. C. Effect of *Endothia parasitica* on conduction. Am. Jour. Bot. 25: 61-65. f. 1, 2. Ja 1938.
- Brierly, W. B. Relation of *Pinus rigida* to physiographic features and soil types in central Massachusetts. Rhodora 40: 72, 73. F 1938.
- Brooks, M. Floral arrangement in *Spiranthes gracilis* (Bigel.) Beck. Castanea 28: 99, 100. D 1937.
- Brown, J. R. Lithops bella. Jour. Cactus & Succ. Soc. Am. 9: 106. illust. Ja 1938.
- Brown, J. R. Notes on haworthias. Jour. Cactus & Succ. Soc. Am. 9: 118, 119. illust. Ja 1938.
- Brown, N. A. Blueberry galls produced by the fungus *Phomopsis*. Phytopathology 28: 71-73. f. 1. Ja 1938.
- Buchholz, J. T. The effects of visible and ultra-violet radiation on the histology of plant tissues. *In Duggar*, B. M. Biological effects of radiation. 829–840. 1936.
- Campbell, W. A. The cultural characteristics of the species of Fomes. Bull. Torrey Club. 65: 31-69. f. 1-128. Ja 1938.
- Campos Porto, P. & Brade, A. C. Orchidaceae novae Brasilienses. II. Arch. Inst. Biol. Veg. Rio de Janeiro. 3: 131-139. pl. 1-3. Au 1937.
- Carroll, J. C. & Welton, F. A. Daily periodicity of stomata in certain species of turf grasses. Bot. Gaz. 99: 420-423. D 1937.
- Cash, E. K. New records of Hawaiian discomycetes. Mycologia 30: 97-107. f. 1-6. Ja-F 1938.
- Cockerell, T. D. A. The botany of the California Islands. Torreya 37: 117-123. N-D 1937.
- Constance, L. A revision of the genus *Douglasia* Lindl. Am. Midl. Nat. 19: 249-259. Ja 1938.
- Cook, O. F. & Joyner, J. F. A diminutive palm from Mayaland. Nat. Hort. Mag. 17: 1-12. f. 1-8. Ja 1938.
- Copeland, H. F. The structure of *Allotropa*. Madroño 4: 137-153. f. 1. pl. 22-26. Ja 1938.

- Cory, V. L. & Parks, H. B. Catalogue of the flora of the State of Texas. Texas Agr. Exp. Sta. Bull. 550: 1-130. f. 1. Jl 1937.
- Crocker, W. Effect of the visible spectrum upon the germination of seeds and fruits. *In Duggar*, B. M. Biological effects of radiation. 791–827. 1936.
- Crocker, W. Growth-promoting action of ethylene and of other chemical substances. Morris Arb. Bull. 1: 77-81. f. 2, 3. Ja 1937.
- Croizat, L. Tithymalus or Pedilanthus? Am. Jour. Bot. 24: 702-704. D 1937.
- Croizat, L. On the prickles and thorns of *Euphorbia*. Desert 9: 127-128. E 1937.
- Currence, T. M. The relation of the first chromosome pair to date of fruit ripening in the tomato (Lycopersicum esculentum). Genetics 23: 1-11. f. 1, 2. Ja 1938.
- Curtis, O. F. Vapor pressure gradients, water distribution in fruits, and so-called infra-red injury. Am. Jour. Bot. 24: 705-710. D 1937.
- Damon, E. B. The concentration effect with *Valonia*: Potential differences with diluted potassium-rich sea waters. Jour. Gen. Physiol. 21: 383-409. 20 Ja 1938.
- De Toni, G. Notes on phycological nomenclature. Rhodora 40:27. Ja 1938.
- Dodge, B. O. A further study of the dry-rot disease of *Opuntia*. Mycologia 30: 82-96. f. 1-5. Ja-F 1938.
- **Drouet, F.** Some Myxophyceae from Nantucket Island, Massachusetts. Rhodora 40: 74–76. F 1938.
- Duggar, B. M. Effects of radiation on bacteria. In Duggar, B. M. Biological effects of radiation. 1119-1149. f. 1-3. 1936.
- Dyer, R. A. A botanical trip from Pretoria through Swaziland, Zululand, and parts of Natal. Jour. Cactus & Succ. Soc. Am. 8: 199-201. illust. Je 1937.
- Dyer, R. A. Botanical exploration in South Africa. [II]. Jour. Cactus & Succ. Soc. Am. 9⁵: 68-70. illust. N 1937; III. Jour. Cactus & Succ. Soc. Am. 9⁶: 83-85. illust. D 1937; IV. Jour. Cactus & Succ. Soc. Am. 9⁷: 99, 100. illust. Ja 1938.
- Eaton, W. P. Wild gardens of New England. 1-124. illust.
 Boston., W. A. Wilde Co. 1936.
- Emmert, E. M. A rapid method for determining carbon in the carbohydrate and protein compounds in plant tissue. Soil Science 45: 67-70. Ja 1938.

- Epling, C. The Labiatae of northern South America. Respert. Spec. Nov. Beih. 95: 5-144. 5 S 1937.
- Epling, C. The California salvias. A review of Salvia, section Audibertia. Annals Missouri Bot. Gard. 25: 95–188. 12–30. + f. 1–14. pl. F 1938.
- Epling, C. The Labiatae of Chile. Rev. Univ. Catolica Chile 23: 167-194. Je-Jl 1937.
- Evans, A. W. Notes on the Cladoniae of Connecticut—III. Rhodora 40: 4-25. Ja 1938.
- Everett, T. H. Plant portraits. Gard. Chron. Am. 42: 9, 10. illust. Ja 1938.
- Eyster, H. C. Conditioning seeds to tolerate submergence in water. Am. Jour. Bot. 25: 33-36. Ja 1938.
- Folsom, D. & Reiner, B. Some properties of potato rugose mosaic and its components. Jour. Agr. Res. 55: 765-793. f. 1-6. 15 N 1937.
- Fosberg, R. F. Some Rubiaceae of Southeastern Polynesia. Bernice P. Bishop Mus. Bull. 13: 245-293. f. 1-15. 5 N 1937.
- Foster, W. R. & Henry, A. W. Overwintering of certain cereal pathogens in Alberta. Canadian Jour. Res. 15: 547-559. f. 1-8. D 1937.
- Fred, E. B., Wilson, P. W. & Wyss, O. Light intensity and the nitrogen hunger period in the Manchu soybean. Proc. Nat. Acad. Sci. 24: 46-52. f. 1. Ja 1938.
- Gager, C. S. The effects of radium rays on plants. In Duggar, B. M. Biological effects of radiation. 987-1013. 1936.
- Gander, F. F. Notes on some San Diego County endemics. Madroño 4: 163-165. Ja 1938.
- Gardner, F. E. & Kraus, E. J. Histological comparison of fruits developing parthenocarpically and following pollination. Bot. Gaz. 99: 355-376. f. 1-17. D 1937.
- Garner, W. W. Photoperiodism. In Duggar, B. M. Biological effects of radiation. 677-713. f. 1. 1936.
- Goodspeed, T. H. Induced chromosomal alterations. In Duggar, B. M. Biological effects of radiation. 1281-1295. f. 1-5. 1936.
- Gowen, J. W. Biological aspects of the quantum theory of radiation absorptions in tissues. *In Duggar*, B. M. Biological effects of radiation. 1311–1330. f. 1-4. 1936.
- Greaney, F. J. The effect of phosphate deficiencies on infection of wheat by *Fusarium culmorum*. Canadian Jour. Res. 16: 27-37. f. 1. Ja 1938.

Groves, J. W. The perfect stage of *Catinula turgida*. Mycologia 30: 46-58. f. 1-8. Ja-F 1938.

Hahn, G. G. & Ayers, T. T. Failure of Dasyscypha Willkommii and related large-spore species to parasitize Douglas fir. Phytopathology 28: 50-57. f. 1. Ja 1938.

Hansen, H. N. & Barrett, J. T. Gardenia canker. Mycologia 30: 15-19. f. 1. Ja-F. 1938.

Hanson, H. C. & Whitman, W. Characteristics of major grassland types in western North Dakota. Ecol. Monog. 8: 57-114. f. 1-11. Ja 1938.

Harrison, B. F. Histological responses of *Iresine lindenii* to indoleacetic acid. Bot. Gaz. 99: 301-338. f. 1-19. D 1937.

Herbst, C. C. & Johnstone, G. R. Life history of *Pelagophycus porra*. Bot. Gaz. 99: 339-354. f. 1-10. D 1937.

Hollaender, A. The problem of mitogenetic rays. In Duggar, B. M. Biological effects of radiation 919-959. f. 1-7. 1936.

Holmes, F. O. Taxonomic relationships of plants susceptible to infection by tobacco-mosaic virus. Phytopathology. 28: 66. f. 1. Ja 1938.

Houk, W. G. Endosperm and perisperm of coffee with notes on the morphology of the ovule and seed development. Am. Jour. Bot. 25: 56-61. f. 1-3. Ja 1938.

Humphrey, L. M. A cytological and morphological analysis of tomato species. Cytologia 8: 306-318. f. 1-27. N 1937.

Hurd-Karrer, A. M. Comparative toxicity of selenates and selenites to wheat. Am. Jour. Bot. 24: 720-728. f. 1-3. D 1937.

Igelsrud, I., Thompson, T. G. & Zwicker, B. M. The boron content of sea water and of marine organisms. Am. Jour. Sci. 35: 47-63. f. 1. Ja 1938.

Inman, O. L., Rothemund, P. & Kettering, C. F. Chlorophyll and chlorophyll development in relation to radiation. In Duggar, B. M. Biological effects of radiation. 1093-1108. 1936.

Jenkins, A. E. & Bitancourt, A. A. An Elsinoë causing an anthracnose on *Hicoria Pecan*. Phytopathology 28: 75-78. f. 1, 2. Ja 1938.

Jenkins, A. E. Elsinoë on lemon fruits from Paraguay. Phytopathology 28: 73-75. f. 1. Ja 1938.

Jepson, W. L. A high school flora for California. 1–223. f. 1–12. Berkeley, California. 30 S 1935.

Jepson, W. L. A flora of California. 2: 1-16. 17 S; 17-176.
f. 128-162. 15 F; 177-336. f. 162-206. 20 Jl; 337-648 f. 206-279. +frontisp. 17 S 1936. San Francisco & Berkeley, California. 1936.

Johnson, E. L. Effects of X-rays upon green plants. In Duggar, B. M. Biological effects of radiation. 961-985. 1936.

Johnson, T. & Newton, M. The origin of abnormal rust characteristics through the inbreeding of physiologic races of *Puccinia graminis Tritici*. Canadian Jour. Res. 16: 38-53. f. 1-5. Ja 1938.

Johnston, E. S. Growth movements in relation to radiation. In Duggar, B. M. Biological effects of radiation. 1073-

1091. f. 1-6. 1936.

Johnston, E. S. Plant growth in relation to wave-length balance. Smithsonian Misc. Coll. 97: 1-18. pl. 1-4. 12 Ja 1938.

Jump, J. A. Further notes on the disease of Himalayan pines. Morris Arb. Bull. 17: 97, 98. Ap 1937.

Keitt, G. W., Blodgett, E. C., Wilson, E. E. & Magie, R. O. The epidemiology and control of cherry leaf spot. Agr. Exp. Sta. Univ. Wisconsin Bull. 132: 1-117. f. 1-19. N 1937.

Kienholz, J. R. & Childs, L. Twig lesions as a source of early spring infection by the pear scab organism. Jour. Agr. Res. 55: 667-681. f. 1-6. 1 N 1937.

Knuth, R. Geraniaceae novae. Kew Bull. Misc. Inf. 1937: 502-505 [D] 1937.

Contributions to the flora of topical America. XXXIII. Plantae Hin-

Koehler, A. The properties and uses of wood. i-xiv, 1-354. f. 1-29. New York. McGraw-Hill Book Co. 1924.

Kolk, L. A. A comparison of the filamentous iron organisms, Clonothrix fusca Roze and Crenothrix polyspora Cohn. Am. Jour. Bot. 25: 11-17. illust. Ja 1938.

Lakela, O. Occurrence of *Poa Chaixii* in America. Rhodora 40: 73. F 1938.

La Rue, C. D. & Avery, G. S. The development of the embryo of Zizania aquatica in the seed and in artificial culture. Bull. Torrey Club 65: 11-21. f. I-8. Ja 1938.

Leonian, L. H. & Lilly, V. G. Partial purification of a vitaminlike substance which stimulates sexual reproduction in certain fungi. Am. Jour. Bot. 24: 700-702. D 1937.

Levine, M. N. & Smith, D. C. Comparative reaction of oat varieties in the seedling and maturing stages to physiologic races of *Puccinia graminis avenae*, and the distribution of these races in the United States. Jour. Agr. Res. 55: 713-729. 15 N 1937.

Lockett, J. L. Nitrogen and phosphorus changes in the decomposition of rye and clover at different stages of growth.

Soil Science 45: 13-24. f. 1. Ja 1938.



- Loehwing, W. F. Photoperiodic stimulus transfer in plants. Science 87: 92, 93. 28 Ja 1938.
- Lyness, A. S. Keys to the ferns of Iowa. Am. Fern Jour. 27: 132-135. 3 Ja 1938; 28: 16-25. Ja-Mr 1938.
- Lyon, C. J. The influence of radiation on plant respiration and fermentation. *In Duggar*, B. M. Biological effects of radiation. 1059-1072. f. 1, 2. 1936.
- Mackay, E. L. Variant chromosome numbers in Spaerocarpos. Bot. Gaz. 99: 377-386. f. 1-24. D 1937.
- Mains, E. B. Two unusual rusts of grasses. Mycologia 30: 42-45. f. 1. Ja-F 1938.
- Mains, E. B. Additional studies concerning the rust of iris— Puccinia iridis. Phytopathology 28: 67-71. Ja 1938.
- Manch, D. Meiosis in an F₁ Viola hybrid and its reciprocal. Am. Jour. Bot. 24: 678-683. illust. D 1937.
- Markwardt, L. J. & Heck, G. E. Standard terms for describing wood. Jour. Forest. 36: 3-11. Ja 1938.
- Marshall, W. T. The golden flowered Huascha. Jour. Cactus & Succ. Soc. Am. 97: 114, 115. illust. Ja 1938.
- Martin, R. F. A new Juncus from Utah. Rhodora 40: 69, 70. illust. F 1938.
- Martin, R. F. Delphinium carolinianum and its allies. Bull. Torrey Club 65: 27-29. Ja 1938.
- Mason, H. L. Two new species of *Linanthus* from western North America. Madroño 4: 157-162. pl. 28. Ja 1938.
- Maxon, W. R. Notes on American ferns. XXI. Am. Fern Jour. 27: 109-111. Ja 1938.
- McVaugh, R. & Pyron, J. H. The distribution of Amphianthus in Georgia. Castanea 28: 104, 105. D 1937.
- McVaugh, R. A new species of Cyperus from the granite region of central Georgia. Castanea 28: 100-104. f. 1-9. D 1937.
- McVeigh, I. Regeneration in *Crassula multicava*. Am. Jour. Bot. 25: 7-11. f. 1-18. Ja 1938.
- Melchers, L. E. & Hansing, E. D. The influence of environmental conditions at planting time on sorghum kernel smut infection. Am. Jour. Bot. 25: 17-28. f. 1, 2. Ja 1938.
- Merrill, E. D. Domesticated plants in relation to the diffusion of culture. Bot. Rev. 4: 1-20. Ja 1938.
- Merrill, E. D. Polynesian botanical bibliography, 1773-1935.

 Bernice P. Bishop Museum Bull. 144: 1-194. Honolulu, Hawaii. 1937.
- Merrill, E. D. Myrtaceae. Mitteil. Inst. Allg. Bot. Hamburg 7: 269. F 1937.

- Merrill, E. D. Rubiaceae. Mitteil. Inst. Allg. Bot. Hamburg 7: 270-301. F 1937.
- Milanez, F. R. Anatomia de lenho de Ampelocera glabra, Kuhlmann. Arch. Inst. Biol. Veg. Rio de Janeiro 3: 211-215. Au 1937.
- Mitchel, J. W. Responses by tomato plants to artificial illumination. Bot. Gaz. 99: 419. f. 1, 2. D 1937.
- Myers, W. M. The nature and interaction of genes conditioning reaction to rust in flax. Jour. Agr. Res. 55: 631-666. pl. 1-3. 1 N 1937.
- Naylor, E. E. & Johnson, B. A histological study of vegetative reproduction in *Saintpaulia ionantha*. Am. Jour. Bot .24: 673-678. f. 1-15. D 1937.
- Neatby, K. W. & McCalla, A. G. Correlation between yield and protein content of wheat and barley in relation to breeding. Canadian Jour. Res. 16: 1–15. f. 1–4. Ja 1938.
- Nebel, B. R. Mechanism of polyploidy through colchicine. Nature 140: 1101. 25 D 1937.
- Nylander, O. O. Castalia tetragona. Salmon Brook Lake bog. 1-9. Caribou, Maine. Ja 1938.
- Olmstead, C. E. Vegetation of certain sand plains of Connecticut. Bot. Gaz. 99: 209-300. f. 1-26. D 1937.
- O'Neill, H. Cyperus pilosus Vahl in the United States. Rhodora 40: 74. F 1938.
- Parker, E. R. Effect of zinc applications on the crop of grape-fruit trees affected with mottle-leaf. Hilgardia 2: 35-52. f. 1-10. D 1937.
- Peebles, R. H. A new Arizona *Opuntia* and related species in series Tortispinae. Jour. Cactus & Succ. Am. 9: 109-111. illust. Ja 1938.
- Penfound, W. T. & Hathaway, E. S. Plant communities in the marshlands of southeastern Louisiana. Ecol. Monog. 8: 1-56. f. 1-17. Ja 1938.
- Pennell, F. W. & Jones, G. N. A new Indian paint brush from Mount Rainier. Proc. Biol. Soc. Washington 50: 207-210. 28 D 1937.
- Perkins, A. E. Echinodorus tenellus, a correction. Rhodora 40: 27. Ja 1937.
- Pessin, L. J. The effect of vegetation on the growth of long-leaf pine seedlings. Ecol. Monog. 8: 115-149. f. 1-8. Ja 1938.
- Plagge, H. H. & Maney, T. J. Factors influencing the development of soggy break-down in apples. Jour. Agr. Res. 55: 739-763. f. 1-7. 15 N 1937.

- Polunin, N. Vascular plants from Mansel (Mansfield) Island, N. W. T. Canadian Field Nat. 52: 5-9. 6 Ja 1938.
- Popp, H. W. & Brown, F. The effect of ultra-violet radiation upon seed plants. *In Duggar*, B. M. Biological effects of radiation. 853–887. 1936.
- Popp, H. W. & Brown, F. Effects of different regions of the visible spectrum upon seed plants. *In Duggar*, B. M. Biological effects of radiation. 763-790. 1936.
- Porsild, A. E. Edible roots and berries of northern Canada. 1–17. f. 1–13. Canada Dep. Mines and Res. Ottawa. 1937.
- Pressley, E. H. A study of the effect of pollen upon the length of cotton fibers. Univ. Arizona Agr. Exp. Sta. Bull. 70: 255-292. pl. 1, 2. f. 1-9. 15 S 1937.
- Reuther, W. & Dickey, R. D. A preliminary report on frenching of tung trees. Univ. Florida Agr. Exp. Sta. Bull. 318:1-21. f. 1-9. D 1937.
- Roberts, R. H. Blossom bud development and winter hardiness. Am. Jour. Bot. 24: 683-685. f. 1-64. D 1937.
- Saunders, A. P. & Stebbins, G. L. Cytogenetic studies in *Paeonia*. I. The compatibility of the species and the appearance of the hybrids. Genetics 23: 65-82. f. 1-4. Ja 1938.
- Schomer, H. A. The effects of radiation on enzymes. In Duggar, B. M. Biological effects of radiation. 1151-1165. f. 1 1936.
- Schuh, R. E. On Pogotrichum filiforme. Rhodora 40: 26 Ja 1938.
- Seaver, F. J. Photographs and descriptions of cup-fungi—XXVIII. A new *Helotium*. Mycologia 30: 79-81. f., 1. Ja-F 1938.
- Shirley, H. L. The effects of light intensity upon seed plants In Duggar, B. M. Biological effects of radiation. 727-762.
- Shive, J. W. & Robbins, W. R. Methods of growing plants in solution and sand cultures. New Jersey Agr. Exp. Sta. Bull. 636: 1-24. N 1937.
- Sinnott, E. W. Laboratory manual for elementary botany. i-ix, 1-106. New York. McGraw-Hill Book Co. 1927.
- Smith, A. H. New and unusual agarics from North America. Mycologia 30: 20-41. f. 1-4. Ja-F 1938.
- Smith, E. C. The effects of radiation on fungi. In Duggar, B. M. Biological effects of radiation. 889-918. 1936.
- Sorokin, H. Mitochondria and plastids in living cells of Allium Cepa. Am. Jour. Bot. 25: 28-33. f. 1-11. Ja 1938.

Sparrow, F. K. The morphology and development of *Obelidium mucronatum*. Mycologia 30: 1-14. f. 1-44. Ja-F 1938.

Spoehr, H. A. & Smith J. H. C. The light factor in photosynthesis. *In Duggar*, B. M. Biological effects of radiation 1015-1058. f. 1-9. 1936.

Sprague, R. Gill fungi associated with the roots of cereals. Phytopathology 28: 78, 79. f. 1. Ja 1938.

Stadler, L. J. Induced mutations in plants. In Duggar, B. M. Biological effects of radiation. 1263-1280. 1936.

Stanfield, J. F. Certain physico-chemical aspects of sexual differentiation in *Lychnis dioica*. Am. Jour. Bot. 24: 710-719. f. 1-3. D 1937.

Stebbins, G. L. Cytogenetic studies in *Paeonia*. II. The cytology of the diploid species and hybrids. Genetics 23: 83-110. f. 1-11. Ja 1938.

Stebbins, G. L. An anomalous new species of Lapsana from China. Madroño. 4: 154-157. pl. 27. Ja 1938.

Stevenson, J. A. A striking disease of Cimicifuga. Claytonia 4: 37-39. f. 1. Ja 1938.

Steyermark, J. A. Najas gracillima in Missouri. Rhodora 40: 28. Ja 1938.

Steyermark, J. A. Two undescribed plants from Arkansas. Rhodora 40: 71, 72. F 1938.

St. John, H. Flora of southeastern Washington and of adjacent Idaho. iii-xxv, 1-531. map. Pullman, Washington. 19 Je 1937.

Stokes, J. Cytological studies in the Myricaceae. Bot. Gaz. 99: 387-399. f. 1-40. D 1937.

Swallen, J. R. Additions to the grass flora of British Honduras. Jour. Washington Acad. Sci. 28: 6-11. 15 Ja 1938.

Tapke, V. F. Physiologic races of Ustilago hordei. Jour. Agr. Res. 55: 683-692. N 1937.

Taylor, W. R. Marine algae of the northeastern coast of North America. i-ix, 1-427. pl. 1-60. Ann Arbor. Univ. Michigan Press. 1937.

Theriot, I. Additions à la flore bryologique de la Colombie. Rev. Bryol. 10: 11-18. f. 1-7. 15 D 1937.

Thornberry, H. H. Crystallization of tobacco-mosaic virus protein. Science 87: 91, 92. 28 Ja 1938.

Torrey, R. H. Cetraria islandica in Sussex County, New Jersey. Torreya 37: 124, 125. N-D 1937.

Trelease, S. F. & Trelease, H. M. Selenium as a stimulating and possibly essential element for certain plants. Science 87: 70, 71. 21 Ja 1938.

- True, R. P. Gall development on *Pinus sylvestris* attacked by the Woodgate peridermium, and morphology of the parasite. Phytopathology 28: 24-49. f. 1-6. pl. 1-3. Ja 1938.
- True, R. H. Himalayan pine. Morris Arb. Bull. 17: 85, 86. illust. Ap. 1937.
- True, R. H. White pine. Morris Arb. Bull. 16: 69, 70. illust. Ja 1937.
- True, R. H. Swiss stone pine. Morris Arb. Bull. 1: 101, 102. Jl 1937.
- Tschudy, R. H. Experimental morphology of some species of *Chaetomium*. II. Reactions of species of *Chaetomium* under various conditions of cultivation. Am. Jour. Bot. 24: 657–665. illust. D 1937.
- Uphof, J. C. T. Cleistogamic flowers. Bot. Rev. 4: 21-49. Ja 1938.
- VanOverbeek, J. A simplified method for auxin extraction. Proc. Nat. Acad. Sci. 24: 42-46. f. 1. Ja 1938.
- Vellasco, E. Hereditariedade da forma da folha do Algodoeiro. Rodriguesia. 2: 197-201. f. 1. S-D 1936.
- Walther, E. Notes on Crassulacea. Jour. Cactus & Succ. Soc. Am. 9: 108. illust. Ja 1938.
- Wei, C. T. Rust resistance in the garden bean. Phytopathology 27: 1090-1105. f. 1. N 1937.
- Wellhausen, E. J. Effect of the genetic constitution of the host on the virulence of *Phytomonas Stewarti*. Phytopathology 27: 1070-1089. f. 1-6. N 1937.
- Wellman, F. L. Poverty of human requisites in relation to inhibition of plant diseases. Science 87: 64, 65. 21 Ja 1938.
- Went, F. W. Transplantation experiments with peas. Am. Jour. Bot. 25: 44-55. f. 1-3. Ja 1938.
- Went, J. C. The influence of various chemicals on the inactivation of tobacco virus. I. Phytopath. Zeits. 10: 480-489. 1937.
- Werdermann, E. Aus den Sammelergebnissen der Reisen von H. Blossfeld und O. Marsoner durch Südamerika. III. Kakteenkunde 11: 161–165. illust. N 1937.
- Wheeler, L. C. Notes on California pteridophytes. Am. Fern Jour. 27: 120-132. Ja 1938.
- Whitford, L. A. A new green alga: Oedocladium Lewisii. Bull. Torrey Club 65: 23-26. pl. 1, 2. Ja 1938.
- Wiant, J. S. Investigations of the market disease of cantaloups and honey dew and honey ball melons. U. S. Dep. Agr. Tech. Bull. 573: 1-47. pl. 1-20+f. 1-15. S 1937.

Williams, L. O. Field and herbarium studies. IV. Ann. Missouri Bot. Gard. 23: 447-456. S 1936.

Wilson, A. The California nutmeg tree in cultivation. Madroño 4: 166, 167. Ja 1938.

Wilson, C. L. The phylogeny of the stamen. Am. Jour. Bot. 24: 686-699. f. 1-52. D 1937.

Wilson, P. W., Burton, J. C. & Bond, V. S. Effect of species of host plant on nitrogen fixation in *Melilotus*. Jour. Agr. Res. 55: 619-629. 15 O 1937.

Wolf, F. A. Life histories of two leaf-inhabiting fungi on sycamore. Mycologia 30: 54-63. f. 1-14. Ja-F 1938.

Worley, C. L. & Mann, L. K. Notes on Idaho ferns. Am. Fern Jour. 27: 112-120. Ja 1938.

Yin, H. C. Diaphototropic movement of the leaves of Malva neglecta. Am. Jour. Bot. 25: 1-6. f. 1-4. Ja 1938.

Youden, W. J. Dilution curve of tobacco-mosaic virus. Contr. Boyce Thompson Inst. 9: 49-58. f. 1-3. Jl-S 1937.

Youden, W. J. Use of incomplete bloch replications in estimating tobacco-mosaic virus. Contr. Boyce Thompson Inst. 9: 41-48. f. 1. JI-S 1937.

Youden, W. J. & Mehlich, A. Selection of efficient methods for soil sampling. Contr. Boyce Thompson Inst. 9: 59-70. f. 1-3. Jl-S 1937.

Young, P. Starch formation in the leucoplasts of *Phaseolus* vulgaris. Bull. Torrey Club 65: 1-8. pl. 1. Ja 1938.



DIRECTORY OF DEALERS

IN MATERIALS OF SCIENCE

The firms listed in this section represent reputable dealers in materials for the laboratory, library, greenhouse, field and garden.

Before you make your purchases consult these firms.

You are assured of courteous treatment and an ample discount.

Mention the BULLETIN

Announcing Publication of Volume 19, Number 1 MEMOIRS OF THE TORREY BOTANICAL CLUB

The Cytology of the Chytridiales, with special reference to Cladochytrium replicatum

By Professor JOHN S. KARLING, Columbia University

This number of nearly 100 pages includes six collotype plates, and is a valuable work on an important group of fungi by an expert in this field.

PRICE \$1.50

Orders should be sent to

Dr. HAROLD N. MOLDENKE, Treasurer
Torrey Botanical Club
New York Botanical Garden, Bronx Park, New York City

Librarians should inform Dr. Moldenke of any standing order which their institution may have for the series of Memoirs.

The American Species of Dryopteris, subgenus Meniscium¹

WILLIAM R. MAXON AND C. V. MORTON (WITH PLATES 11-14)

With the exception of the subgenus *Meniscium* the American ferns of the genus *Dryopteris* were treated monographically by Christensen in 1907, 1913, and 1920. His work upon this difficult group, which had been distinguished (even among the ferns) for its widely overlapping and confused specific concepts and its exceedingly complicated synonymy, was based upon an enormous amount of material brought together from the larger European herbaria and the U. S. National Museum, and is of outstanding importance and permanent value. *Meniscium* was omitted because the series of specimens at hand was not sufficiently comprehensive.

That a revision of *Meniscium* is still sorely needed was brought home to us forcefully in a recent effort to identify an interesting Ecuador specimen collected by Mrs. Ynes Mexía, and the present paper has resulted from an effort to reduce the existing confusion. For the loan of much recent and valuable material we are indebted to the following institutions: Botanisches Museum, Berlin; Botanisk Museum, Copenhagen; Field Museum of Natural History; Gray Herbarium of Harvard University; Royal Botanic Gardens, Kew; New York Botanical Garden.

The first knowledge of a fern of this group comes from Plumier,² who in 1693 gave a description and plate of a plant called Filix latifolia, non ramosa nigris tuberculis pulverulenta. The same plate (with a slightly amplified description) was reproduced by him in 1705³ under the name Lingua cervina nigris tuberculis pulverulenta. A little later Petiver⁴ depicted the same species under the name Phyllitis ramosa striis undulatis. From the nomenclatural point of view, the first species to be proposed was that described by Linnaeus⁵ as Polypodium reticulatum, his description reading as follows: "P. frond. pinnatis oblongis integris, anastomosantibus rectangulis, punctis rectangulis approximatis. Plum. t. 9."

Later, Jacquin⁶ described from Martinique a species which he called Asplenium sorbifolium, citing the same Plumier plate that formed the basis

- ¹ Published by permission of the Secretary of the Smithsonian Institution.
- ² Description des Plantes de l'Amérique 6. pl. 9. 1693.
- 3 Traité des Fougères de l'Amérique 92. pl. 110. 1705.
- ⁴ Pteridographia Americana pl. 7, fig. 1. 1712.
- ⁵ Syst. Nat. ed. 10, 2: 1325. 1759.
- ⁶ Coll. Bot. 2: 106. pl. 3, fig. 2. 1788.

[THE BULLETIN FOR MAY (65: 267-345) WAS ISSUED MAY 18, 1938]

of Polypodium reticulatum L. Jacquin's own description and figure leave no doubt that his species is identical with that of Linnaeus, a fact duly recognized by Schreber⁷ in proposing the genus Meniscium. His description is as follows: "Meniscium Schreb. Asplenium Jacq. Coll. 2 t. 3. f. 2 Polypodium reticulatum L. Capsulae congestae in lunulas, venulis frondis interjectis." The type species of Meniscium is therefore Polypodium reticulatum L.

The genus *Meniscium* was promptly accepted and its validity was not questioned for nearly 70 years. It was still recognized by Mettenius in 1856,⁸ but in 1859⁹ he reversed his earlier opinion and united it with *Phegopteris*, a procedure entirely contrary to our modern ideas of nomenclature, inasmuch as *Phegopteris* dates, as a genus, only from 1852. In any case Mettenius' systematic views were not shared by Hooker and Baker, who continued to recognize the genus *Meniscium*, a usage which occasionally continued as late as 1910. A union of this group of species with *Nephrodium* was proposed by Keyserling¹⁰ and accepted by Diels.¹¹ Transfers to *Dryopteris* were first made by Urban¹² and were continued by Christensen in the Index Filicum.

Within the genus Dryopteris, the subgenus Meniscium is most closely related to Goniopteris section Microdictyon, which includes D. Poiteana (Bory) Urban, D. Liebmanni Maxon & Morton, 13 and D. Ghiesbreghtii (Linden) C. Chr. These species all have essentially meniscioid venation, but are distinguished from true Meniscium by their paired sori, which have the receptacle more or less elevated and rotund, never elongate. Such sori are not found in Meniscium except sporadically and, presumably, as an atavistic condition. Moreover, all species of Goniopteris have stellate hairs, at least on the rhizome scales, but these have not been found in Meniscium, except in D. Desvauxii forma glandulosa, in which a very few large multiradiate hairs are on close examination occasionally to be seen near the base of the costules.

An affinity with the subgenus Stigmatopteris is also evident through the aberrant species D. Christii C. Chr., which was described by Baker as Meniscium opacum. Here the venation is meniscioid and the receptacle

- ⁷ Linnaeus, Gen. Plant. ed. 8, 2: 757. 1791.
- 8 Filices Lechlerianae, part 1. 1856.
- ⁹ Op. cit. part 2. 1859.
- 10 Polypod. Cyath. Herb. Bung. 1873.
- ¹¹ Die Natürlichen Pflanzenfam. 1: pt. 4. 1899.
- 12 Symb. Antill. 4: 1903.
- 13 Dryopteris Liebmanni Maxon & Morton, nom. nov.

Polypodium meniscioides Liebm. Dansk. Vid. Selsk. Skrift. V. 1: 211. 1849. Dryopteris meniscioides C. Chr. Ind. Fil. 277. 1905, not Kuntze (1891).

elongate, but the nearer relationship with *Stigmatopteris* is evident in the glabrous lamina, which is regularly pinnatifid at apex, rather than imparipinnate, and in the presence of scales along the costules. In *Meniscium* scales along the costae and costules are never found. Even along the rachis and stipe they are usually caducous.

The Old World species which have been referred to *Meniscium* are considerably different from any American species and are, as Christensen¹⁴ suggested, probably not to be associated in the same subgenus with them.

The first comprehensive account of *Meniscium* was by Fée, ¹⁵ who listed 15 species, seven of which were new. He divided the species into two sections, one strictly Old World, characterized by having the sporangium-sac setose, the other, entirely American, with non-setose sporangium-sac. The American species were in turn divided into two groups, one characterized by hirsute sori, the other by glabrous sori. Fée's keen discernment of these critical differences was unjustly ignored by subsequent fern students. The hirsute character of the sori of certain species is usually obvious, even on casual inspection. A closer examination shows that the setiform hairs arise, not from the receptacle, but from the sporangium stalks near their apex. These we believe to afford an important character, separating the species into natural groups. The species proposed by Fée are mostly valid, although some of his names are antedated by those of other authors.

In determining the presence or absence of setae on the stalks of the sporangia a close scrutiny with the higher power of a dissecting microscope is often necessary, although in *Dryopteris Hostmanni*, *D. permollis*, and *D. Desvauxii* the setae are usually clearly visible with a hand lens or even with the naked eye. In counting the number of areoles and the number of lateral veins within a space of three centimeters we have selected the middle or lower portion of middle or lower pinnae of mature plants, inasmuch as the areoles are naturally fewer and the veins closer together near the apex of the pinnae, and of course the same condition is found in upper or juvenile pinnae.

The following account is far from satisfactory, owing partly to the lack of complete material suitable for comparison, the fronds as a rule being coarse and ill-suited to collecting in their entirety. In particular, a number of critical specimens from Bolivia have necessarily been left unplaced. Certain species also, like D. Jurgensenii and D. Desvauxii, are remarkably variable in size and general appearance. On the whole, however, the species are more readily recognizable than is indicated by the key. Their

¹⁴ Monogr. Dryopteris 1: 268. 1913.

¹⁵ Gen. Fil. 221-225, 1852.

number is almost certain to be increased, when additional material from Bolivia and several other regions becomes available for study.

KEY TO SPECIES

KEY TO SPECIES
Fronds simple
Blades large (up to 60 cm. long and 12.5 cm. broad), acummate, the interns appressed pubes-
Blades small (up to 12.5 cm. long and 4 cm. broad), caudate-acuminate, the midrib glabrous; stipes lustrous, glabrous, naked
stipes lustrous, glabrous, naked
Fronds pinnate
Pinnae uncinate-serrate, at least toward apex.
Upper pinnae often reduced; pinnae gradually attenuate from a broad base, mostly stalked, the uppermost sessile; veins and usually the leaf tissue strongly pubescent. 5. D. serrata
Upper pinnae not reduced; pinnae very narrowly oblong, rather abruptly acuminate-caudate at apex, mostly sessile, several of the uppermost semiadnate to short-decurrent; veins
and leaf tissue glabrous
Pinnae undulate, crenulate, or usually subentire.
Stalk of sporangium without hairs.
Disease 2 5 investe
Blades conform; pinnae 4.5-7.5 cm. broad; lateral veins of fertile pinnae 4-11 pairs per 3 cm.; areoles 13-20-seriate.
Pinnae rounded, obtuse, or broadly cuneate at base, subsessile; lateral veins 8–11 pairs
per 3 cm.; sporangia aggregate in single linear sori
Pinnae cuneate, the lower ones strongly so, stalked (up to 2.5 cm.); lateral veins 4-6
pairs per 3 cm.; sporangia often arranged in paired sori
pairs per 3 cm.; sporangia often attained in paned series of fertile ninnae 13-18
Blades subdimorphic; pinnae 2.5-4.5 cm. broad; lateral veins of fertile pinnae 13-18
pairs per 3 cm.; areoles 7–10-seriate
Pinnae many-jugate.
Areoles of sterile pinnae almost as long as broad, the secondary veins nearly straight.
Pinnae linear, often falcate.
Pinnae entirely glabrous, the lower ones subcordate, sessile 10. D. ensiformis
Pinnae hairy on veins, the lower ones cuneate at base, long-petiolate
Areoles of sterile pinnae much shorter than broad, the secondary veins curving and
arcuate subsigmoid.
Sterile pinnae up to 22 cm, long and 3 cm, broad; lateral veins of fertile pinnae 12-18
pairs per 3 cm. (except in <i>D. nesiotica</i>); areoles 4-12-seriate; fertile pinnae con-
tracted and much smaller than the sterile, except sometimes in D. Salzmanni.
Sterile pinnae 1–2 (2.3) cm. broad, subequally cuneate at base, mostly stalked,
the basal ones strongly so; areoles 4–8-seriate. Lateral veins of sterile pinnae
11–18 pairs per 3 cm.; pinnae long-attenuate
Sterile pinnae 1.7–3 cm. broad, obtuse or rounded at base, or oblique at upper side,
sessile: areoles 8–12-seriate.
Pinnae long-attenuate; lateral veins of fertile pinnae 8 pairs per 3 cm
Pinnae acute or short-acuminate; lateral veins of fertile pinnae 12–16 pairs per 3 cm
Sterile pinnae often over 30 cm. long, 3.5-6.5 cm. broad, long-acuminate; lateral veins
of fertile pinnae 7–10 pairs per 3 cm.; areoles 13–22-seriate; fertile pinnae usually conform with sterile.
Pinnae broadest at middle
Pinnae broadest at middle
Finilize broadest in lower time

Stalk of sporangium bearing near apex 1 or more sharply pointed setae (obvious as hairs among the sporangia) or (in *D. Desvauxii* f. *glandulosa*) these rarely with a blunt glandular apex.

Blades subdimorphic, the fertile pinnae suffused with sporangia; sterile pinnae much larger (mostly 5–7 cm. broad).

Blades not dimorphic, the fertile pinnae usually with discrete sori; sterile pinnae commonly less than 4 cm. broad (up to 6 cm. in *D. membranacea*).

Areoles 3-5-seriate; pinnae rounded-auriculate at base, slightly constricted above base
14. D. dispar

Areoles 7-20-seriate; pinnae not auriculate, not constricted above base

Lower pinnae rounded at base, sessile or nearly so; areoles 11-20-seriate.

Lower pinnae cuneate at base, petiolulate; areoles 5-12-(rarely 15-) seriate.

Leaf surface hairy, often densely and softly so, or the hairs replaced by capitate glands.

Pinnae large (usually over 20 cm. long and 3 cm. broad), the lowest with a petiolule at least 1 cm. long.

1. DRYOPTERIS LINGULATA C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. 102: 271, 1913.

In this species the arcuate venules are often sterile at the middle and thus have a pair of sori, instead of a single linear sorus. This condition is occasionally noted in other species also and can not be considered as of special significance, except perhaps as indicating that *D. lingulata* is one of the more primitive species of this alliance. The paired sori are always elongate, and never have a definite rotund receptacle as in *Goniopteris* or in some of the Old World species that have been referred to *Meniscium*.

We have examined the following specimens:

Costa Rica: Valley of Río Hondo, near Madre de Diós, in forest, alt. 200 meters, *Pittier* 10349, type coll. (US). Hamburg Finca, on Río Reventazón below Cairo, Prov. Limón, alt. 55 meters, in wet forest, *Standley & Valerio* 48659 (US). Finca Hundrisser, *Brade* 306 (Y).

Panama: Foothills of Garagará, Sambu Basin, southern Darien, alt. 30-500 meters, *Pittier* 5596 (US).

COLOMBIA: Tutenendo, 20 km. north of Quibdó, Intendencia del Chocó,

alt. 80 meters, Archer 2130 (US). Landázuri region, Dept. Santander, alt. 300 meters, along streams, Mrs. Geo. L. Green 51 (US).

PERU: San Antonio, on Río Itaya, Dept. Loreto, alt. 110 meters, in dense forest, Killip & Smith 29378 (US.)

2. DRYOPTERIS ANDREANA (Sod.) C. Chr. Ind. Fil. 252. 1905.

Meniscium Andreanum Sod. Recens. 71. 1883; Crypt. Vasc. Quit. 392. 1893.
Phegopteris Andreana Christ in Pitt. Prim. Fl. Costar. 3: 35. 1901, as to name.

Dryopteris Andreana var. glabra Hieron. Hedwigia 46: 352. 1907.

Founded on specimens collected along the Río Toachí, near Santo Domingo, Ecuador, and known to us only from that country.

Undoubtedly *D. Andreana* is most closely related to *D. lingulata* C. Chr., which is of very similar aspect but may be distinguished by the cuneate-based petiolulate lower pinnae, those of *D. Andreana* being rounded and sessile. We consider this an important character in *Meniscium*. The Costa Rican record for *D. Andreana*, published by Christ, was based on *Pittier* 10349, a collection which later served as the type of *D. lingulata*.

ECUADOR: In silv. apud Los Colorados, Oct. 1883, Sodiro (K, 3 sheets). In silv. reg. Angamarca, Nov. 1900, Sodiro 310 (Y, 3 sheets). In silv. trop. sec. fl. Pilatón, 1899, Sodiro (Y). In silv. trop. et subtrop., alt. 400–1800 m., Sodiro (US). Base of Mt. Chimborazo, alt. 900 m., July 1860, Spruce 5739 (K). Near Mindo, Stübel 767 (B, type of D. Andreana var. glabra). Nanegal, Sodiro 54/6 (K). Road from Quito to Manaby, Sodiro 54/8 (K).

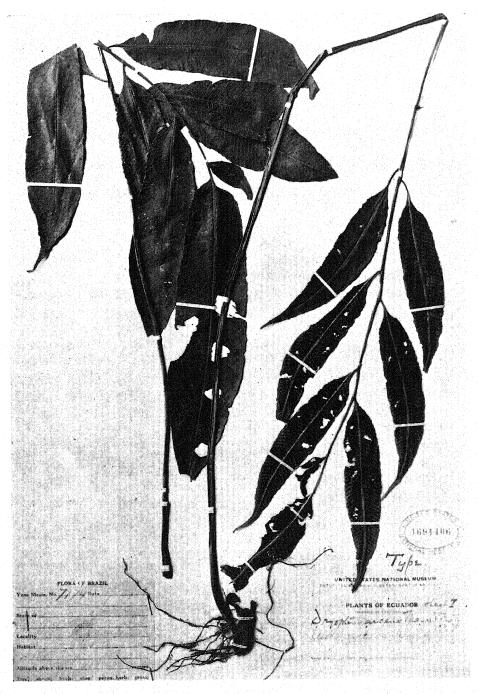
3. Dryopteris arcana Maxon & Morton, sp. nov.

PLATE 11

Rhizoma breviter repens, vix 1 cm. diam. Folia usque ad 85 cm. longa, laxe suberecta, subbiformia, omnino glabra, stipitibus e basi fusca dilute olivaceis sulcatis, eis foliorum sterilium laminas subaequantibus, eis fertilium quam laminis multo longioribus; lamina 1-pinnata; pinnae 2 vel 3-jugae et terminalis conformis major, infimae plerumque suboppositae, ceterae alternae et remotae. Laminae steriles ambitu orbiculari-ovatae, 18–30 cm. longae, 14–20 cm. latae, rachi tenui; pinnae obliquae, margine subintegrae, auguste oblongae, 10–18 cm. longae, 2.5–4.5 cm. latae, apice longe acuminatae, basi subanguste cuneatae, infimae petiolulatae (3–9 mm.); venae laterales ca. 50-jugae, spatio 3 cm. 10–13, sub angulo 60° egredientes, prominulae; venulae sub angulo 45° eductae, angulo recto vel subacuto conjunctae, subtus promin-

Explanation of Plate 11

Plate 11. Dryopteris arcana Maxon & Morton, sp. nov. The type specimen; Ecuador, Mexia 7174. About half natural size.



MAXON & MORTON: DRYOPTERIS

ulae; areolae 7–10-seriatae, venulis excurrentibus elongatis liberis; parenchyma chartacea. Laminae fertiles ovatae vel oblongae; pinnae porrectae, margine irregulariter repando-crenatae, plerumque lanceolatae, 7–12 cm. longae, 1.5–2.5 cm. latae, in apicem caudatum sensim attenuatae, basi anguste cuneatae, plerumque breviter petiolulatae (infimae usque ad 1 cm.); venae laterales spatio 3 cm. 13–18, subflexuosae; venulae sub angulo lato egredientes, arcuatim conjunctae; areolae 8–10-seriatae, breves, plerumque fertiles; sori oblongi, brunnei, discreti sed vetuste interdum subconfluentes.

Type in the U. S. National Herbarium, no. 1,691,406, collected on the trail from Tena to Napo, Province of Napo-Pastaza, Ecuador, at an altitude of 400 meters, on a steep wet bank in shade, April 5, 1935, by Mrs. Ynes Mexía (no. 7174). Two additional specimens of this number have furnished data for the description.

Dryopteris arcana is not closely related to the other pinnate species, but shows an undoubted affinity with D. minuscula, despite the simple fronds of the latter. The veins diverge at a much wider angle, however, and the pinnae are not abruptly caudate, as is the blade of D. minuscula.

4. DRYOPTERIS MINUSCULA Maxon, Kew Bull. Misc. Inf. 1932: 135. 1932.

This species, evidently rare, is known only from the type material at Kew, which was found by Lehmann (no. 4433) on moist earth banks and rock walls along the Río Dagua, coastal region of Buena Ventura, Colombia. It is by no means closely related to *D. simplicifrons*, the only other species with simple fronds, from which it differs in aspect, size, and gross morphology too widely for comparison, as well as in its non-appendiculate sporangia. Its relationship is doubtless with *D. arcana*, as mentioned.

5. DRYOPTERIS SERRATA (Cav.) C. Chr. Ind. Fil. 291. 1905.

Meniscium serratum Cav. Descr. Pl. 548. 1803.

Meniscium dentatum Presl, Del. Prag. 1: 162. 1822.

Meniscium palustre Raddi, Opusc. Sci. Bol. 3: 284. 1819; Pl. Bras. 1: 9. pl. 20. 1825.

Meniscium rostratum Fée, Gen. Fil. 224. pl. 18 B, fig. 3. 1852.

Phegopteris palustris Mett. Fil. Lechl. 2: 24. 1859.

Phegopteris serrata Mett. Ann. Sci. Nat. V. Bot. 2: 243. 1864.

Nephrodium serratum Keys. Pol. Cyath. Herb. Bung. 49. 1873.

Dryopteris reticulata var. serrata Farwell, Amer. Midl. Nat. 12: 292. 1931. Thelypteris serrata Alston, Kew Bull. Misc. Inf. 1932: 309. 1932.

The present species, described originally from Habana, is exceedingly variable, but, though widely distributed, it gives no evidence of regional segregation. A distinctive character is found in the margins, which, at least near the apex of the pinnae, are uncinate-serrate. From *D. consobrina*,

the only other species with similar margins, *D. serrata* is distinguished by the key characters. Occasionally the margins are deeply jagged and erose-serrate. In certain other species of *Meniscium* the margins are often crenate or crenulate, especially in the fertile pinnae, but only in this species and *D. consobrina* are they ever truly serrate. Sometimes also, as in other species, minutely paleaceous buds are borne on the costae of the lower pinnae, at or just above their base. These occasionally develop into small plants. An extreme case is shown by a frond from Morro das Pedras, State of São Paulo, Brazil, *Brade* (Y), in which the young plants are 15 cm. high.

As to range: D. serrata occurs in Florida, but is uncommon in the West Indies, except in Trinidad; on the continent it ranges from Mexico to Paraguay and Argentina, being abundant in Brazil. Material of this species has mostly not been borrowed by us. The following list includes the numbered specimens examined, these mainly in the National Herbarium:

FLORIDA: Southern shore of Lake Okeechobee, *Harshberger* in 1912 (Y).

JAMAICA: Wilson 518; Bot. Dept. 332; Sherring.

Cuba: Léon 2404; Hioram & Maurel 4698.

PUERTO RICO: Sintenis 6378. Guadeloupe: Duss 1612.

Trinidad: Fendler 57 (9 sheets); Britton, Hazen, & Freeman 948; Hart 554; Broadway 2778; Jenman; Kuntze.

Mexico: Fisher 35387; Orcutt 6628; Purpus 8602; Ross 1064; C. L. Smith 2111.

GUATEMALA: Barber 167; Kellerman 7360; Lundell 3297; Maxon & Hay 3056; J. D. Smith 2421.

Honduras: Ames 172; Dyer A 146; Standley 53701, 53784; Thieme (J. D. Smith 5660 and 5695); Yuncker 5049.

Costa Rica: Pittier 10265; J. D. Smith 6934; M. Valerio 19, 891; Werckle.

PANAMA: Bailey 401, 476; Dodge 3453; Kenoyer 23; Killip 2819; Maxon 4782, 6723; Seibert 641; Skutch 2; Stork 105.

COLOMBIA: H. H. Smith 1055; Killip & Smith 14924; Haught 1596; Holton 30; Pennell & Rusby 51; Schott.

VENEZUELA: Rusby & Squires 378; Pittier 10879.

British Guiana: Gleason 471, 786; De La Cruz 3449; Graham 379; Jenman.

French Guiana: Sagot 720.

Brazil: Burchell 1529, 9882; Dusén 11469, 14733; Haerchen (Rosen-

stock 72); Liitzelburg 12918; Martius 357; Pickel 2251; Regnell III. 1444 in part; Schmalz 57; L. B. Smith 2008; Wacket 96.

PARAGUAY: Balansa 2830; Fiebrig 999; Hassler 1539, 4835, 5476; Jor-

gensen 4607.

Argentina: Orán, El Cedral, Prov. Salta, Rodriguez 1035. Alrededores de Posadas, Misiones, Nuñez 234.

ECUADOR: Balao, Eggers 14396.

Peru: Killip & Smith 27036; Klug 431; L. Williams 4236.

BOLIVIA: Bang 554 in part; Steinbach 7500.

6. Dryopteris consobrina Maxon & Morton, sp. nov.

Rhizoma deest. Folia suberecta, usque ad 2.15 m. longa, stipitibus validis (maximis 115 cm. longis, basi 1 cm. diam.), e basi brunnea dilute brunnescentibus, crasse angulato-sulcatis, primum tenuiter et minute puberulis; lamina 1-pinnata, late oblonga, usque ad 1 m. longa et 70 cm. lata, rhachi stipiti simili; pinnae 9-11-jugae et terminalis conformis, subpatentes (maximae 25-30 cm. longae et 3.5-5 cm. latae), anguste lineari-oblongae, apice acuminato-caudatae, basi modice rotundatae vel interdum subabrupte et late cuneatae, subaequales, pleraeque sessiles, solum subapicales plurimae postice semiadnatae, omnes margine callosa argute dentato-serratae, serraturis imprimis pinnae apicem versus uncinatis, parenchyma glabra; venae laterales infra acuminem 60-65-jugae, plerumque 6-8 spatio 3 cm. (raro usque ad 13), sub angulo 70° egredientes, utrinque prominulae, leviter falcatae, subtus pilis obliquis brevibus perpaucis praeditae; areolae 12-22-seriatae, breves, steriles venulis inaequalibus obliquis formatae, fertiles venulis sub angulo latissimo eductis et arcuatim conjunctis formatae; sori anguste oblongi, propinqui sed vetuste etiam non confluentes; sporangia glabra.

Type in the U. S. National Herbarium, nos. 1,464,533 and 1,464,534 (a sterile frond) and no. 1,692,123 (basal portion of a fertile frond), collected in a wooded valley near La Merced, Dept. Junín, Peru, altitude about 700 meters, June 4, 1929, by E. P. Killip and A. C. Smith (no. 24087). Duplicate in herb. New York Botanical Garden. Other specimens examined:

Peru: Type locality, Killip & Smith 23514 (US, Y). Río Apurimac Valley, near Kimpitiriki, alt. 400 meters, edge of dense forest along beach, Killip & Smith 22945 (US, Y).

In its uncinate-serrate margins the present species resembles *D. serrata*, from which, highly variable though the latter is, it is readily distinguished as above indicated. The Apurimac Valley specimen (Killip & Smith 22945) clearly belongs to *D. consobrina*, but it is under-sized and its dimensions are not included in the description.

7. Dryopteris Salzmanni (Fée) Maxon & Morton, comb. nov.

Meniscium Salzmanni Fée, Gen. Fil. 223. 1853. Meniscium elongatum Fée, Crypt. Vasc. Brés. 1: 83. pl. 25, fig. 1. 1869. ?Meniscium sessilifolium Pohl; Fée, op. cit. 84.

This species was described by Fée from Bahia material collected by Salzmann. It has very generally been disregarded, most specimens having been referred to *D. reticulata*, which in every way is a much larger plant. The pinnae of *D. Salzmanni* are more rigid and ascending and have fewer, more acute areoles. The relationship is probably somewhat closer to *D. serrata* than to *D. reticulata*.

Specimens examined are as follows:

Brazil: State of Bahia: Bahia, Salzmann, type coll. (B, C, Y); Glocker 189 (K). State of Rio de Janeiro: Without locality, Glaziou 1169, type coll. of M. elongatum (C); Serra dos Orgaos, near Pereira, Lützelburg 6024 (C, US); Corcovado, Voy. Herald 167 (K); Organ Mts., alt. 1000–1500 meters, Rose & Russell 20803 (US, Y); Mt. Itatiaya, alt. 800 meters, L. B. Smith 1648 (C, US). State of Minas Geraes: Viçosa, alt. 680 meters, Mexia 4683 (US), 4857a (US); Lagoa Santa, Warming 793 (C, 4 sheets). State of Maranhao: Victoria Alto Parnahyba, Snethlage 724 (F). State of São Paulo: Campinas, Ulbricht (Rosenstock 215) (US). Without locality, Glaziou 15744 (C).

COLOMBIA: Without locality, Funck & Schlim in 1862 (Y).

Peru: Pampayaco, alt. 1050 meters, *Macbride* 5046 (US). Zepelacio, near Moyobamba, alt. 1100–1200 meters, *Klug* 3354 in greater part (K, US, Y). Valley of Pillahuata, Province of Paucartambo, *Herrera* 1622 (US).

8. DRYOPTERIS TURRIALBAE Rosenst. Repert. Sp. Nov. Fedde 22: 10. 1925.

A Costa Rican form, described from specimens collected on the lower Atlantic slopes near Turrialba, altitude 650 meters, Aug. 1909, by Alfredo and Curt Brade (no. 357). It is by far the most weakly characterized of any of the species here recognized and may prove no more than a geographic variety of the West Indian *D. reticulata*, from which it differs mainly in the shape of the pinnae. The following collections have been studied:

Costa Rica: Turrialba, alt. 650 meters. A. & C. Brade 357, type coll. (Y); Banks of Río Colorado, near Turrialba, alt. 600 meters, Tonduz 8287 (US). Tuis, Prov. Cartago, alt. 650 meters, Tonduz 11321 (K, US); same, distributed as J. D. Smith 7325 (K, US).

9. Dryopteris reticulata (L.) Urban, Symb. Antill. 4: 22. 1903.

Polypodium reticulatum L. Syst. Nat. ed. 10, 2: 1325. 1759.

Asplenium sorbifolium Jacq. Coll. Bot. 2: 106. pl. 3, fig. 2. 1788.

Meniscium sorbifolium Dessrous. in Lam. Encyl. 4: 93. 1797.

Meniscium Schreberi Rich. Act. Soc. Hist. Nat. (Paris) 1: 114. 1792 (nomen nudum).

Meniscium reticulatum Sw. Journ. Bot. Schrad. 18012: 274. 1803.

Diplazium undulosum Sw. Syn. Fil. 92, 284. 1806, in part (as to Plum. Trait. Foug. pl. 107).

Meniscium acrostichoides Desv. Mém. Soc. Linn. Paris 6: 223. 1827.

Phegopteris reticulata Mett. Fil. Lechl. 2: 24. 1859.

Phegopteris sorbifolia Mett. op. cit. 23.

Nephrodium reticulatum Keys. Pol. Cyath. Herb. Bung. 49. 1873.

Nephrodium sorbifolium Hieron. Bot. Jahrb. Engler 34: 449. 1904, as to name; not Presl (1825).

Dryopteris reticulata var. sorbifolia Suesseng. Rev. Südamer. Bot. 1: 82. 1934.

As previously stated, the sole basis of Linnaeus' description of *Polypodium reticulatum* is the Plumier illustration (plate 9, republished as plate 110). This was cited also under *Asplenium sorbifolium* by Jacquin, whose diagnosis leaves no doubt that he was redescribing the Linnaean species under another name. This identity was recognized by early authors; but later writers, beginning perhaps with Schott, wrongly associated the name *sorbifolium* with a South American species (*D. Hostmanni*) that is not very closely related to *D. reticulata* and is not known to occur in the West Indies. Still later the name came to be applied generally but very mistakenly to the species which we here call *D. permollis*.

Due allowance being made for age and varying habitat, *D. reticulata* is a very constant species. The following specimens, mainly in the National Herbarium, have been examined:

FLORIDA: Alapattah, on cypress knees, Eaton 779 (US, Y).

Jamaica: Alexander; Clute 149; Fredholm 3209; Maxon 1004, 1710, 2282, 2371, 2552, 8948, 9358, 10323; Maxon & Killip 24, 502, 1542; Underwood 2986; Watt 162.

Cuba: Britton et al. 5142, 7537, 14742; Clément 1313; Eggers 5019; Hioram 1396, 6457; Linden 2116; Maxon 4208, 4254; Palmer & Riley 82, 917, 1026, 1048; Pollard et al. 48; Shafer 4366, 8568, 8955, 10651, 10688, 13689; Wright 782, 1084.

HISPANIOLA: Abbott 37, 74, 77, 610, 746, 1442, 2166; Eggers 2315; Ekman 3823, 11549; Fuertes 1682; Leonard 9188; Miller 1162; Nash & Taylor 1053; Valeur 336, 827.

Puerto Rico: Britton et al. 8398; Eggers 724; Fisher 69 in part; Goll 682; Heller 1034; Hioram 87; Shafer 3232; Sintenis 132, 2338, 6584; Slevenson 6120; Underwood & Griggs 267, 530.

LEEWARD ISLANDS: St. Kitts, Box 263; Britton & Cowell 181. Guadeloupe, Stehlé 511, 654, 1096, 1876. Dominica, Bailey 763.

WINDWARD ISLANDS; Montserrat, Miller 1924; Ryan 169; Shafer 202, 736, 738; Turner. Martinique, Duss 1611; Hahn 29; Isert in 1787; Miller in 1924; Thiébaut in 1876. St. Vincent, Guilding. Grenada, Eggers 6057; Murray & Elliott 11; Sherring 35. St. Lucia, Box 452, 491.

ISLAND OF MARGARITA (Venezuela); Juan Griego trail, alt. 450 meters, Johnston 166 (6 sheets). El Valle, Miller & Johnston 156 (3 sheets).

The altitudinal range is from sea-level to a maximum of 900 meters.

10. DRYOPTERIS ENSIFORMIS C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. 10²: 269. fig. 46. 1913.

Founded on a Costa Rican plant (Tonduz 12533), and now to be reported also from Peru and Venezuela. We regard this as an excellent species, although the points stressed by Christensen do not seem of special significance. These were: (1) The presence of an aerophore, (2) the cartilaginous margins, and (3) the long excurrent venules, which often are extended to the next cross-veins. The aerophore was not seen but was postulated from the presence of a dark spot upon the rachis at the base of the pinnae. This was considered to be the scar of a fallen aerophore. But these spots are to be observed in most if not all species of Meniscium, and although we have examined a great amount of material we have found no evidence of aerophores. On the contrary these dark spots themselves, which are verruculose, presumably function as ventilation areas. Cartilaginous margins are common to other large coarse species of Meniscium. As to venation, the fact that the excurrent venules are sometimes united to form a more or less continuous intermediate vein parallel to the true lateral veins is not a distinctive character, this condition being quite as common in D. Jurgensenii. In the type collection of D. ensiformis the sori are commonly though not always paired, but this is not true in other specimens of this species. As mentioned under D. lingulata, paired sori in this group may be regarded as an abnormal atavistic condition.

Dryopteris ensiformis is most closely related to D. Jurgensenii, from which it differs in having the pinnae sessile and subcordate at base (in decided contrast to the cuneate-based, long-stalked lower pinnae of the latter), and in its wholly glabrous blades, at least a few hairs being found along the costae and veins of D. Jurgensenii.

The following specimens have been examined:

Costa Rica: Lisière des Paturâges à La Palma, alt. 1459 meters, Tonduz 12533, type coll. (C, US); C. Brade 104 (US). Without locality, Werckle (US).

Peru: Schunke Hacienda, above San Ramón, Dept. Junín, alt. 1400–1700 meters, in forest, Killip & Smith 24651 (US, Y).

VENEZUELA: Near Tovar, Fendler 232 in part (B).

11. Dryopteris Jurgensenii (Fée) Maxon & Morton, comb. nov.

Meniscium falcatum Liebm. Dansk. Vid. Selsk. Skrift. V. 1: 183. 1849.

Meniscium Jurgensenii Fée, Gen. Fil. 223. 1852 (as M. Jungersenii).

Phegopteris falcata Mett. Fil. Lechl. 2: 23. 1859.

Dryopteris pachysora Hieron. Hedwigia 46: 351. pl. 7, fig. 9. 1907.

Dryopteris sorbifolia var. confertivenosa Hieron. op. cit. 350.

Dryopteris sorbifolia var. punctivenulosa Hieron. loc. cit.

Dryopteris falcata C. Chr. Dansk. Vid. Selsk. Skrift. VII. Naturv. Afd. 10²: 270. 1913, not Kuntze (1891).

The present species, latterly recognized as valid, was first described as *Meniscium falcatum* Liebm., but unfortunately this epithet is invalid under *Dryopteris*. *Meniscium Jurgensenii* Fée, founded on *Jurgensen* 917 from Mexico, is obviously the same.

Dryopteris Jurgensenii is now found to be common, ranging from southern Mexico to Bolivia. In spite of very considerable extremes in size, the specimens here cited are relatively constant in venation. The venules are straight or nearly so and meet at a broad angle, and the false intermediate lateral veins sometimes formed by the intermittently joined excurrent venules imperfectly divide the areoles into trapeziform halves. This is markedly different from the condition seen in D. reticulata, D. Salzmanni, and most other species, in which the venules are obviously curved (subsigmoid), at least in the sterile pinnae.

The following specimens have been examined:

Mexico: Near Lacoba, Distr. Chinantla, Puebla, alt. 600-750 meters, Liebmann 679, 680, 2756, type of M. falcatum (C, K, US).

BRITISH HONDURAS: Big Creek, near sea level, along river banks, Schipp 97 (C, F, K, US).

GUATEMALA: Near Finca Sepacuité, Cook & Griggs 667 (US). Livingston, Deam 453 (Y). Sierra del Mico, alt. 600 meters, Kellerman 7212 (F). Puerto Barrios, at sea level, Standley 25003 (US), 25017 (US). Cubilquitz, Alta Verapaz, alt. 350 meters, Tuerckheim (J. D. Smith 8039) (US).

NICARAGUA: Castillo El Viejo, along Río la Juana, Shimek (F). San Juan del Norte, C. L. Smith 2030 (US, Y).

COSTA RICA: Llanuras de San Carlos, alt. 200 meters, Brade 485 (Y).

Pejivalle, Lankester 819 (US). Buenos Aires, in forest, Pittier 4839 (US). El General, Prov. San José, alt. 950 meters, Skutch 2181 (US).

Panama: Chagres, Fendler 404 (K, US). Near Laguna de Chiriquí, Hart 16 (US). Hilly forest near Las Cascadas, Canal Zone, alt. 50–225 meters, Maxon 4895 (US). Along Río Culebra, above Santa Isabel, Prov. Colón, near sea level, Pittier 4153 (US). Near San Felix, eastern Chiriquí, Pittier 5209 (US).

COLOMBIA: Bay of Utria, Seemann (K). Monte la Tortuga, García 4600 (US). Puerto Berrio, Dept. Santander, alt. 100-700 meters, Haught 1842 (US). Chocó, Schott 24 & s. n. (F, US, Y); Seemann 972 (K). Between Honda and Bogotá, Stübel 392, type of D. sorbifolia var. confertivenosa (B). Near Muzo, Dept. Cundinamarca, Stübel 544, type of D. sorbifolia var. punctivenulosa (B). Without locality, Lehmann 5034 (K, US); Mutis 3299 (US).

PERU: East of Quimirí Bridge, near La Merced, Dept. Junín, alt. 800-1300 meters, in forest, Killip & Smith 23890 (US, Y). Pichis Trail, Yapas, Dept. Junín, alt. 1350-1600 meters, in forest, Killip & Smith 25570 (US, Y).

BOLIVIA: Hacienda Simaco, on road to Tipuani, alt. 1400 meters, Buchtien 5158 (C, US, Y). Apolo, alt. 150 meters, R. S. Williams 1254 (Y).

Dryopteris angustifolia (Willd.) Urban, Symb. Antill. 4: 21. 1903.
 Meniscium angustifolium Willd. Sp. Pl. 5: 133. 1810.
 Phegopteris angustifolia Mett. Fil. Lechl. 2: 22. 1859.

This species, here taken up in the usual sense, was founded on a Caracas specimen collected by Bredemeyer. It had been described and illustrated originally by Sloane¹⁶ as "Filix major in pinnas tantum divisa oblongas angustatas, non crenatas." Both specimens have been examined by the senior author, at Berlin and the British Museum (Natural History).

Dryopteris angustifolia is common in the Greater Antilles, ascending from sea level to about 700 meters, but is unknown from the Lesser Antilles. On the continent it ranges from Costa Rica to Paraguay, reaching an altitude of 1100 to 1400 meters in Colombia, but oddly enough is apparently wanting in Brazil. In all probability the continental range could be considerably amplified by examining material in other herbaria. Most of the following specimens are in the U. S. National Herbarium.

Jamaica: Clute 270; Crawford 805; Hart 346; Maxon 799, 1824, 8851; Maxon & Killip 144.

Cuba: Clément 1785; Hioram 1479; Maxon 4319; Wright 781.

HISPANIOLA: Abbott 2017, 2579; Ekman 5638, 12298; Leonard 8730, 12296; Miller 1133; Nash & Taylor 1221; Valeur 319.

¹⁶ Nat. Hist. Jamaica 1: 84. pl. 40. 1707.

Puerto Rico: Britton et al. 3935, 8429, 8580; Dale 10; Eggers 1336; Heller 1398; Hess 339; Hioram 264; Shafer 3144; Sintenis 4547, 4657; Wilson 53, 348.

Mexico: Lacoba, Chinantla, Puebla, *Liebmann*. Guatemala: Near Mazatenango, *Bernoulli* 446.

COSTA RICA: La Fortuna, Biolley in 1906. Pasoagres, near Alajuela, Lankester 605.

Panama: Chagres, Fendler 397. Juan Diaz River, Killip 2559. Río Tapia, Prov. Panamá, Standley 28122. Obispo, Canal Zone, Standley 31692.

COLOMBIA: Santa Marta, Mrs. Dora Bennett 29; Niemeyer 36; H. H. Smith 1053. East of Zarzal, Dept. El Valle, Pennell, Killip & Hazen 8538, 8583. Without locality, Mutis 3284. Dibulla, Dept. Magdalena, Seifriz 279 in part.

PERU: Río Paucartambo Valley, near Perene Bridge, Dept. Junín, Killip & Smith 25260. Chazuta, Río Huallaga, Dept. San Martín, Klug 4035. San Buenaventura, Cárdenas 1899.

BOLIVIA: Mapiri, alt. 650 meters, Tate 413 (Y). PARAGUAY: Sierra de Amambay, Hassler 10508 (K).

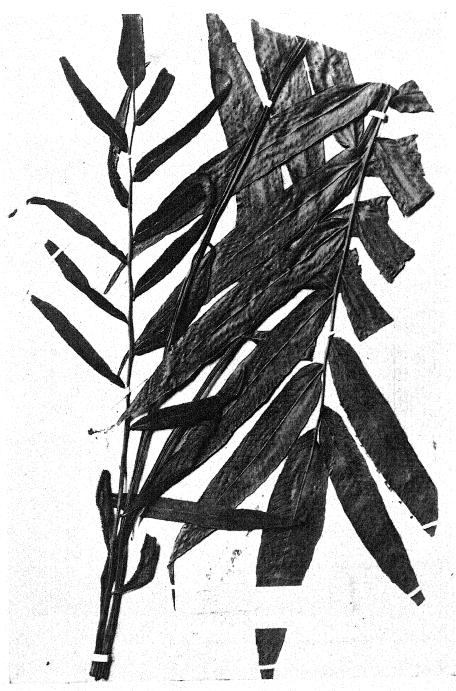
13. Dryopteris nesiotica Maxon & Morton, sp. nov.

PLATE 12

Rhizoma deest. Folia rigide suberecta, usque ad 95 cm. longa, subbiformia, stipitibus validis, pallide brunneis, profunde et anguste sulcatis, cum rhachi minute puberulis, eis foliorum sterilium quam laminis multo brevioribus, eis fertilium laminas subaequantibus; lamina 1-pinnata; pinnae 9-11-jugae et terminalis conformis, adscendentes, integrae, inferiores plurimae suboppositae, ceterae alternae. Laminae steriles ambitu late oblongae, 40-55 cm. longae, ca. 30 cm. latae; pinnae subaequales, 16-22 cm. longae, 2.5-3 cm. latae, late lineares, parte apicali longe attenuatae, basi obtusae vel rotundatae, vel superiores antice obliquae, hae postice plus minusve adnatae, ceterae sessiles (infimae brevissime petiolulatae exceptae); venae laterales infra acuminem ca. 40-jugae, spatio 3 cm. ca. 8, sub angulo 60°-70° egredientes, leviter falcatae, fere glabrae, utrinque prominulae; venulae leviter curvatae, sub angulo 45° eductae, inaequales, angulo subrecto conjunctae, utrinque prominulae; areolae 9-11-seriatae, breves, venulis excurrentibus brevibus. Laminae fertiles oblongae; pinnae remotae, lineares, 9-13 cm. longae, attenuatae, basi inaequaliter subcuneatae, sessiles (superiores semiadnatae exceptae); sporangia glabra, areolarum arcum totum insidentia, creberrima et numerossisima, pinnae pagina inferiori (costa excepta) suffusa.

Explanation of Plate 12

Plate 12. Dryopteris nesiotica Maxon & Morton, sp. nov. The type specimen; Trinidad, Jenman. About half natural size.



MAXON & MORTON: DRYOPTERIS

Type in the herbarium of the New York Botanical Garden, collected in Trinidad by G. S. Jenman, together with a second specimen which is evidently of the same collection.

The present species is allied to *D. angustifolia*, but is at once distinguished by its broad sterile pinnae, which except for the basal pair are neither stalked nor cuneate, and by its distant lateral veins.

14. Dryopteris dispar Maxon & Morton, nom. nov.

Meniscium affine Presl ex Ettingsh. Denkschr. Akad. Wiss. Math. Naturw. (Wien) 23: 94. pl. 13, fig. 3. 1864; Farnkr. Jetztw. 170. fig. 73; pl. 135, fig. 16. 1865. Not Dryopteris affinis Newm. 1854.

Since its original publication this species, from "Brazil," has remained unknown, having been described inadequately on characters of venation only and without citation of specimens. We give here an amplified description:

Stipe about equaling the blade, slender (2 mm. in diameter), stramineous, lustrous, glabrous; blades imparipinnate, oblong in outline, 50 cm. long, 20 cm. broad, the rachis stramineous, lustrous, glabrous; pinnae 9-jugate, sub-opposite, membraneous, linear-falcate, up to 14.5 cm. long and 1.7 cm. wide, acuminate-attenuate in apical fourth, subsessile, at base obtuse and rounded-auriculate on both sides; margins subentire; leaf surface, costae, and veins glabrous except for scattered whitish stipitate glands, the lateral veins about 11 pairs in the space of 3 cm.; venules almost straight, meeting each other at an obtuse angle, the areoles 4–6-seriate; sori not confluent; sporangium stalk setose.

The above description is drawn from a specimen in the Kew Herbarium collected on bank of the Río Mauhy, in the state of Amazonas, Brazil, by J. W. H. Traill (no. 1402). It does not agree exactly with the plate of Ettingshausen, for in that the areoles are only 3- or 4-seriate and the bases of the pinnae not auriculate. In the present specimen the areoles are mostly 5-seriate. However, since no other species has so few areoles and the plants otherwise are in close general agreement, we believe the identification to be correct.

15. DRYOPTERIS SIMPLICIFRONS C. Chr. Ind. Fil. 486. 1906.

Meniscium giganteum Mett. Fil. Lechl. 1: 19. 1856.

Phegopteris gigantea Mett. Fil. Lechl. 2: 22. 1859.

Nephrodium giganteum Diels in Engl. & Prantl, Pflanzenfam. 14: 177. 1899; not Baker (1867), Baker (1874), nor Cesati (1877).

Dryopteris gigantea C. Chr. Ind. Fil. 267. 1905; not Kuntze (1891).

This well-known species, founded on material from St. Gavan, Peru (Lechler 2292), is at once recognized by its large simple fronds. Christensen intimates that pinnately divided forms are found, but we have seen no specimens so named nor any that can be referred to this species. Such material would very likely be referable to D. Andreana or D. membranacea. The closer relationship of D. simplicifrons is undoubtedly with the latter, with which it agrees in having appendages borne on the stalk of the sporangium. In D. membranacea these are in the form of sharply pointed hyaline setae, whereas those of D. simplicifrons are stalked capitate glands. The stalk of the gland is often rather long, and the gland itself is large, spherical and of a dark red color. At first these glands are very conspicuous among the sporangia, but they appear to be readily deciduous and are not to be seen on older specimens.

Unfortunately the specific name gigantea, being preoccupied for an Old World Tectaria, can not be retained for the present species, the "new combination" Dryopteris gigantea (Mett.) C. Chr. having been published in spite of Dryopteris gigantea Kuntze (1891), which is listed on the same page. In a succeeding fascicle of the Index Filicum (p. 486), which appeared the next year (1906), the new name Dryopteris simplicifrons is validly published by Christensen as the equivalent of Phegopteris gigantea Mett. and this, though it has subsequently been ignored by Christensen himself and by other writers, must now be taken up.

Dryopteris simplicifrons inhabits dense humid forests, from lower altitudes to about 1500 meters. It ranges from Costa Rica to Peru, but is yet to be found in Panama. The following specimens have been studied:

COSTA RICA: Forest above Tsaki, Talamanca, alt. 500 meters, *Tonduz* 9448. Peralta, alt. 600-700 meters, *Lankester*. Without locality, *Werckle*.

COLOMBIA: Along Río Guatapé, Dept. Antioquia, alt. 1040 meters, Kalbreyer 1453 (K). "Ciñegetas," Dept. Antioquia, alt. 1200-1500 meters, Kalbreyer 1865 (K). Along Río Timbiquí, near Coteje, Dept. Cauca, alt. 100-500 meters, Lehmann 8946 (K, US); also Lehmann as B. T. 444 (K, US).

ECUADOR: Forests at 300-1200 meters, Aug. 1875, Sodiro 54 (K, 3 sheets).

PERU: St. Gavan, in shady wet forests, Lechler 2292, type coll. (K). Pichis Trail, San Nicolas, Dept. Junín, alt. 1100 meters, Killip & Smith 26018 (US).

16. DRYOPTERIS MEMBRANACEA (Mett.) C. Chr. Ind. Fil. Suppl. 35. 1913.
PLATE 13

Phegopteris membranacea Mett. Fil. Lechl. 2: 22. 1859.

Nephrodium Lechleri Hieron. Bot. Jahrb. Engler 34: 448. 1904. Dryopteris Lechleri C. Chr. Ind. Fil. 274. 1905.

Phegopteris membranacea was described by Mettenius with citation of two Peruvian specimens collected by Lechler, viz. (1) no. 1785, from Azangaro, which he had previously listed 17 as M. reticulatum, and (2) an unnumbered specimen from St. Gavan. His description is ample and clearly applies to the species subsequently described as Nephrodium Lechleri by Hieronymus, who based his description upon Lechler 1785, from Azangaro. and Lechler 2321, from St. Gavan, the latter being presumably the second specimen cited by Mettenius as P. membranacea. In so doing Hieronymus appears to have regarded the Berlin material as an aggregate and to have fallen into the error of selecting typical membranacea for description as a new species, wrongly applying the name membranacea to another Lechler specimen from St. Gavan, viz. no. 2493. A photograph of no. 2493 has kindly been forwarded from Berlin. It shows a large sterile blade, with nine pairs of pinnae below the greatly enlarged pinnatifid apex. The specimen thus disagrees widely with Mettenius' description, does not bear an annotation by him, and certainly was not included in his original concept of P. membranacea. If not actually teratological, it is at least highly atypical for any known member of this genus and can not at present be placed specifically.

Thus, Nephrodium Lechleri and Dryopteris Lechleri are exactly the equivalent of D. membranacea and, having been based on the same specimens as that, are illegitimate. Technically, according to Article 60 of the International Rules of Nomenclature, they may be disregarded.

We have seen only the following specimens, though Hieronymus lists this species (as D. Lechleri) from Ecuador on the basis of Stübel 1002.

COLOMBIA: Between Pueblo Viejo and San Miguel, Dept. Magdalena, alt. 900–1700 meters, *Seifriz* 556 (US).

Peru: In rupibus umbrosis prope Azangaro, *Lechler* 1785, type coll. (K, 2 sheets). Mishuyacu, near Iquitos, alt. 100 meters, in forest, *Klug* 200 (US); *Klug* 1533 (US, Y). Chazuta, Río Huallaga, Dept. San Martín, alt. 260 meters, in forest, *Klug* 3970 (US, Y). Mt. Campana, near Tarapoto, *Spruce* 4645 (K, US).

Reference of the last collection to *D. membranacea* is somewhat doubtful, on account of its conspicuously strigose costae and veins. The speci-

17 Fil. Lechl. 1: 19. 1856.

Explanation of Plate 13

Plate 13. Dryopteris membranacea (Mett.) C. Chr. Isotype specimen, at Kew; Peru, Lechler 1785. About half natural size.



MAXON & MORTON: DRYOPTERIS

mens are very immature, however, and are only slightly more hairy than one of the two specimens of *Lechler* 1785, this also being very young, with most of the sporangia undeveloped.

17. Dryopteris Standleyi Maxon & Morton, sp. nov.

Rhizoma deest. Folia conformia, rigide suberecta, usque ad 1.9 m. longa. stipitibus validis, quam laminis multo longioribus, e basi fusca pallide brunnescentibus vel ochraceo-stramineis, obtuse angulatis, minute et laxe puberulis; lamina 1-pinnata. Laminae steriles late oblongae, usque ad 50 cm. longae et 40 cm. latae, apice acutiusculae vel abrupte acutae; pinnae 12-17-jugae et terminalis conformis, subpatentes, subimbricatae, margine subintegrae vel leviter repandae, pleraeque superiores sensim minores, ceterae subaequales, ligulatae, 12-22 cm. longae, 2.5-4 cm. latae, apice acutae vel attenuatae, basi late rotundatae vel pleraeque subcordatae, omnes sessiles; venae laterales spatio 3 cm. 9-13, sub angulo 60° egredientes, utrinque prominulae, subtus cum venulis pilis curvatis brevibus paucis praeditae; venulae sub angulo 35°-40° eductae, longae, acutissime conjunctae; areolae 9-14-seriatae, breves, profunde antice curvatae, venulis excurrentibus plerumque longis sed liberis; parenchyma chartacea, pilis rigidis parvis hinc inde praedita, mox glabrescens. Laminae fertiles anguste oblongae, usque ad 70 cm. longae et 40 cm. latae, apice abrupte acutae; pinnae obliquae, ca. 17-jugae et terminalis, sterilibus similes sed plerumque angustiores (maximae 22 cm. longae et 2.5-4 cm. latae), apice attenuatae, basi non reductae, sessiles, margine irregulariter sinuatae vel crenatae, superiores paulum minores; venae laterales spatio 3 cm. 13-15, sub angulo 75° egredientes, prominulae, subtus cum venulis pilos breves paucos ferentes; venulae sub angulo ca. 45° eductae, rectae, angulo obtuso conjunctae, venulis excurrentibus liberis hydathoidis linearibus terminatis; areolae 11-14-seriatae, dimidiis trapeziformibus; sori magni, late oblongi, crebri, aetate confluentes, sporangiorum pedicellis setis rigidis solitariis vel binis supra instructis.

Type in the U. S. National Herbarium, nos. 1,150,894-6, representing two complete fronds (fertile and sterile), collected on a brushy bank near Quiriguá, Dept. Izabal, Guatemala, altitude 75 to 225 meters, May 15-31, 1922, by Paul C. Standley (no. 24126). Other specimens examined are as follows:

Mexico: Cerro de Tonala, in a forest ravine, C. & E. Seler 2013 (US). Colombia: Near Onaca, Santa Marta, alt. 750 meters, boggy situations in "open land" ravines, H. H. Smith 2458, 7 specimens (F, US, Y).

Peru: Zepelacio, near Moyobamba, Dept. San Martín, alt. 1100 to 1200 meters, *Klug* 3354 in part (U. S.).

BOLIVIA: San Carlos, Mapiri region, alt. 850 meters, *Buchtien* 228 (G). Closely related to the present species is a form from Taboga Island, Panama (*Killip* 2642; *Standley* 28025), which very likely is specifically

distinct. It is similar in venation but is definitely pilosulous beneath, in strong contrast to the essentially glabrous leaf tissue of *D. Standleyi*. The Killip specimen is remarkable also for its widely distant pinnae.

18. Dryopteris Hostmanni (Klotzsch) Maxon & Morton, comb. nov.

PLATE 14

? Meniscium arborescens Humb. & Bonpl.; Willd. Sp. Pl. 5: 133. 1810. Not Dryopteris arborescens Kuntze (1891).

Polypodium Hostmanni Klotzsch, Linnaea 20: 397. 1847.

Meniscium Kapplerianum Fée, Gen. Fil. 224. 1852.

? Phegopteris arborescens Mett. Fil. Lechl. 2: 24. 1859.

? Dryopteris reticulata var. arborescens Brause, Verh. Bot. Ver. Brand. 51: 2. 1910.

Polypodium Hostmanni Klotzsch was described from Surinam upon material collected by Hostmann and Kappler (no. 828), and the same number served also as the sole basis of Meniscium Kapplerianum Fée. Whether Meniscium arborescens Humb. & Bonpl. is the same appears to be highly problematical. Not only Humboldt and Bonpland but Mettenius, who saw the plant in cultivation, describe it as arborescent. In the specimens of D. Hostmanni that we have seen there is no evidence of such a development, otherwise unknown in Meniscium; yet Hieronymus also regarded arborescens and Hostmanni as synonymous. In any case, the name arborescens is not available, being preoccupied by Dryopteris arborescens (Baker) Kuntze, 1891, applied to a Samoan plant.

The specimens cited below are of uniform facies, one of the largest being a frond collected by Jenman, in which the pinnae are 2 to 2.5 cm. broad. Sporangium setae are conspicuous in all.

PANAMA: Río Cañazas, Prov. Veraguas, Allen 164 (US).

DUTCH GUIANA: In sylvis humidis, *Hostmann & Kappler* 828, type coll. (B, K, Y). Without locality, *Wullschlaegel* (F, Y).

British Guiana: Pirana, Appun 1469 (K). Rockstone, in dense upland forest, Gleason 609 (US, Y). Demerara River, Jenman (Y, 2 sheets); Jenman 3845 (K).

19. Dryopteris Desvauxii Maxon & Morton, nom. nov.

and the same of th

Meniscium longifolium Desv. Mém. Soc. Linn. Paris 6: 223. 1827.

Meniscium longifolium Fée, Crypt. Vasc. Brés. 1: 84. pl. 25, fig. 2. 1869.

Nephrodium longifolium Hieron. Bot. Jahrb. Engler 34: 449. 1904.

Dryopteris longifolia (Fée) Hieron. Hedwigia 46: 351. 1907.

Dryopteris reticulata var. longifolia (Desv.) Rosenst. in Buchtien, Contr. Fl. Bol. 1: 44. 1910.

The present species offers an unusual problem in nomenclature, recently discussed by Mr. C. A. Weatherby¹⁸ in his paper on the ferns proposed by Desvaux as new. Both Desvaux and Fée described independently this fern under the same name, *Meniscium longifolium*, but upon different material. Fée's name is a later homonym, yet Hieronymus in transferring the species to *Dryopteris* used it, rather than the *longifolium* of Desvaux. Since Fée's epithet is illegitimate, the new combination made by Hieronymus under *Dryopteris* is equally so; nevertheless it makes impossible the transfer now of the epithet given by Desvaux. A new name must therefore be given, as above.

As here considered *D. Desvauxii* shows great variability. It is close to *D. permollis*, though typical specimens of the two are quite different. Usually it is a much larger plant, with longer-stalked pinnae, and a shorter less dense pubescence. Especially noteworthy is the presence of stalked capitate glands, which normally replace the hairs of the leaf surface to a considerable extent. In some specimens all the hairs are replaced by glands, in which case the plants appear so different that their formal recognition seems desirable. The following specimens of the typical form have been examined:

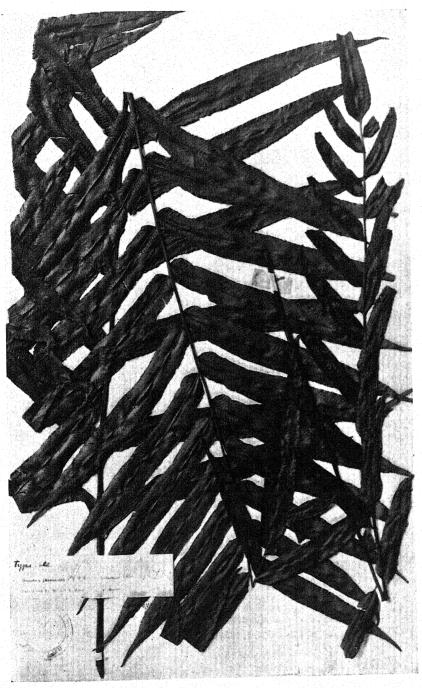
Brazil: State of Amazonas: Manaos, Gleason 11 (Y); Barra do Rio Negro, Spruce 1243 (K); near San Gabriel, along Rio Negro, Spruce 2141 (K, US). State of Para: Near Gurupatuba, west of Monte Alegre, Traill 1403 (K). State of Ceara: Serra de Araripa, Gardner 1904 (K). State of Goyaz: Glaziou 22633 (B, K). State of Espirito Santo or Bahia: Blanchet 3984 (C, K). State of Minas Geraes, Regnell III. 1444 in part (US). Rio de Janeiro: Organ Mts., Gardner 103 (K); Valence, Glaziou 1747, type coll. of M. longifolium Fée (C, K, US); without definite locality, Glaziou 2375, paratype coll. of M. longifolium Fée (C, K); Petropolis, Spannagel 523 (Y). State of Paraná: Jacarehy, Dusén 6580 (B, F, US); Serra do Mar, Porto de Cima, Dusén 14679 (C, F); Alexandra, Dusén 10159 (B, K, US), 15258 (F). State of Santa Catharina: Joinville, etc. Schmalz, partly as no. 166 (F, US, Y). Without locality, Burchell 2635 (K); Glaziou 15743 (C), 15745 (C).

Bolivia: San Antonio, near Mapiri, Buchtien 1063 (US). Roboré,

¹⁸ Contr. Gray Herb. 114: 27. 1936. A photograph of Desvaux's type specimen has very kindly been furnished by Mr. Weatherby.

Explanation of Plate 14

Plate 14. Dryopteris Hostmanni (Kl.) Maxon & Morton. Isotype specimen, at Kew; Dutch Guiana, Hostmann & Kappler 828. About half natural size.



MAXON & MORTON: DRYOPTERIS

Cárdenas 2991 (US). Buena Vista, Dept. Santa Cruz, Steinbach 5312 (US). San José, R. S. Williams 1245 (US, Y).

19a. Dryopteris Desvauxii f. glandulosa Maxon & Morton, forma nov.

Lamina pilis destituta, glandulis stipitatis capitatis albidis instructa.

Type in herbarium of the New York Botanical Garden, collected at Morro das Pedras, São Paulo, Brazil, February 1928, by Brade (no. 5753). Other specimens examined are as follows:

Brazil: State of Goyaz, Glaziou 22632 (F, Y). State of São Paulo: Santos, Lindberg 545 (K). State of Paraná: Alexandra, Dusén 15258 (US). 19

BOLIVIA: Mapiri, alt. 480 meters, R. S. Williams 1281 (Y).

Peru: Mishuyacu, near Iquitos, Dept. Loreto, alt. 100 meters, Klug 509 (US).

20. Dryopteris permollis Maxon & Morton, nom. nov.

Phegopteris mollis Mett. Ann. Sci. Nat. V. Bot. 2: 242. 1864. Not Dryopteris mollis (Jacq.) Hieron. 1907.

Nephrodium sorbifolium var. molle f. angustipinnata Hieron. Bot. Jahrb. Engler 34: 449. 1904.

Dryopteris sorbifolia var. mollis Hieron. Hedwigia 46: 351. 1907.

This species, as *Phegopteris* (Meniscium) mollis, was well described by Mettenius upon material from Llano de San Martín, Paraiso, Colombia, alt. 300 meters, collected by Triana. It was reduced to varietal rank by Hieronymus under both Nephrodium sorbifolium and Dryopteris sorbifolia; but Meniscium sorbifolium is exactly synonymous with D. reticulata, as discussed under that species, and is not closely related to the present plant. Mettenius' epithet, mollis, being preoccupied under Dryopteris, a new one is required.

Usually *D. permollis* is readily recognized by its densely soft-pilose under surfaces. Capitate glands are sometimes found among the hairs, but not so commonly as in *D. Desvauxii*. The following specimens have been examined:

Costa Rica: Buenos Aires, in forest along the Río Ceibo, *Pittier* 4852 (US).

COLOMBIA: Type collection, *Triana* (US). Cali, *André* 429 (F, K, US, Y); *Lehmann* 2937 (K, US). Intendencia del Chocó, along Río Atrato, *Archer* 1808 (US). Río Pauca, *Dryander* 631 (US). Buenaventura, Dept.

¹⁹ A specimen of this number (with identical data) in Field Museum is typical D. Desvauxii.

El Valle, Killip 11683 (US); Pennell & Killip 5295 (US, Y). Mesa de los Santos, Dept. Santander, Killip & Smith 15248 (US, Y). Villavicencio, Pérez 10 (US). San Carlos, Dept. Antioquia, Kalbreyer 1376 (K).

British Guiana: Marima, Appun 1058 (K).

PERU: Pampayacu, Kanehira 129 (US).

Bolivia: San Carlos, near Mapiri, Buchtien 241 (Y). Antahuacana, Buchtien 2210 in part (US). Ticunhuaya, Tate 1062 (Y).

The altitudinal range is from sea level to about 1500 meters.

To this species is perhaps to be referred a specimen in the Kew Herbarium collected at Tovar, Venezuela (*Fendler 232* in part), in which almost all the hairs are suppressed, the veins being conspicuously stipitate-glandular.

21. Dryopteris chrysodioides (Fée) Maxon & Morton, comb. nov.

Meniscium chrysodioides Fée, Gen. Fil. 225. 1852.

Fée's description is brief and is followed by the statement, "Habitat in America australi. (Collect. Pamplin., in Herb. cl. Moug., no. 55," neither the country nor collector being indicated.²⁰ This species has never before been placed very definitely, being listed in the Index Filicum as a synonym of *D. reticulata*; but upon reading Fée's comment, "aspectu *Chrysodii vulgaris*," it occurred to us independently to associate the name with several British Guiana specimens collected by Jenman, which indeed bear a general resemblance to *Acrostichum aureum* (*Chrysodium vulgare*). They agree well with Fée's description and represent a very well marked species, which presumably attains a greater size than indicated by the description or by Jenman's specimens. These are as follows:

British Guiana: Pomeroon River, Jenman 2072 (K); Jenman s. n. (Y, 2 sheets). Mazaruni River, Jenman in 1881 (Y).

Of this species the following is a well-marked variety. It is based on

²⁰ The following comment on Fée's statement is obligingly furnished by Dr. J. H. Barnhart: "I understand by this that the Mougeot Herbarium contained a collection distinguished as the 'Collectio Pampliniana' and that the specimen in question was either no. 55 of that collection or had had that number assigned to it by Mougeot. The only botanist by the name of Pamplin known to me is William Pamplin, who was an Associate of the Linnaean Society for almost 70 years, and died in 1899 in his ninety-third year. For 23 years (1839–62) he was a book dealer in London, specializing in botanical books, and it would not be at all strange if Mougeot received from him either by gift, exchange, or purchase a collection of botanical specimens. I do not think that Pamplin was ever in any part of America. He traveled all over Great Britain, studying its flora, but I have no evidence that he even crossed the Channel to the Continent." To this Mr. C. A. Weatherby adds that Pamplin's herbarium was purchased by G. C. Druce and is presumably at Oxford University.

Glaziou 22631, which Christensen mentioned as probably representing an undescribed species.

21a. Dryopteris chrysodioides var. goyazensis Maxon & Morton, var. nov.

Filix maxima, pinnis alternis multijugis ligulatis, sterilibus usque ad 40 cm. longis et 7 cm. latis subintegris acuminatis basi rotundatis breviter petiolulatis subtus praecipue in venis breviter pilosulis, venis primariis 5 vel 6 in spatio 3 cm., venulis subsigmoideis, areolis 16–19-seriatis, pinnis fertilibus minoribus usque ad 23 cm. longis et 4.5 cm. latis margine crenatis subtus dense pilosis; sori confluentes; sporangiorum pedicellus apice setosus.

Type in herbarium of the New York Botanical Garden, collected in the valley of the Rio Corumba, State of Goyaz, Brazil, July 23, 1894, by M. A. Glaziou (no. 22631). Duplicates of this collection are at Copenhagen and Field Museum. Other specimens are as follows:

British Guiana: Appun 844 (K, 3 sheets).

Brazil: State of Bahia, Blanchet 1023 (Y). Matto do Curupira, State of Matto Grosso, Lindman A 3043 (US). Without locality, Riedel 59 (US).

This variety differs from the typical form of *D. chrysodioides* in its larger and more numerous sterile pinnae and in its strongly crenate fertile pinnae. From *D. membranacea*, which in some ways it resembles, it differs in having the fertile pinnae smaller than the sterile and conspicuously crenate, and in its confluent sori.

DOUBTFUL AND EXCLUDED SPECIES

MENISCIUM CRISTATUM Desr. in Lam. Encycl. 4:94. 1797.

This is Diplazium cristatum (Desr.) Alston, Journ. Bot. Brit. & For. 74: 173. 1936.

Meniscium Fendleri Eaton ex C. Chr. Ind. Fil. 421, 1906.

According to Christensen the citation is Bot. Gaz. 3: 89. 1878, but no such name appears at this place. The species is *Bolbitis macrophylla*.

MENISCIUM GUYANENSE Fée, Gen. Fil. 224. 1852. This is *Bolbitis macrophylla*.

MENISCIUM "PUNCTA LUNULATUM Rich." ex C. Chr. Ind. Fil. 421. 1906. At the place cited by Christensen, viz., Act. Soc. Hist. Nat. (Paris) 1: 114. 1792, this is by no means intended as a species name but is merely the first part of the generic description of *Meniscium* given by Richard.

Bolbitis macrophylla (Kunze) Maxon & Morton, comb. nov.

Meniscium macrophyllum Kunze, Flora 221: Beibl. 44. 1839.

Heteroneuron meniscioides Fée, Hist. Acrost. 93. pl. 55. 1845.

Poecilopteris meniscioides Presl, Epim. Bot. 175. 1851.

Meniscium guyanense Fée, Gen. Fil. 224. 1852.

Phegopteris macrophylla Mett. Fil. Lechl. 2: 24. 1859.

Nephrodium macrophyllum Keys. Pol. Cyath. Herb. Bung. 48. 1873.

Acrostichum Fendleri Baker, Journ. Bot. Brit. & For. 25: 100, 1887.

Meniscium oligophyllum Hort. ex Baker, Ann. Bot. 5: 487. 1891.

Leptochilus Fendleri C. Chr. Bot. Tidsskr. 262: 285. 1904.

Dryopteris macrophylla C. Chr. Ind. Fil. Suppl. I. 35. 1913.

Dryopteris anceps Maxon, Contr. U. S. Nat. Herb. 24: 62. 1922.

Close study of a large series of specimens convinces us that this species may not be retained in *Dryopteris*. The sporangia are not borne on a definite receptacle, as in all species of that genus, but are regularly distributed over the whole leaf surface. A few species of *Meniscium*, such as *D. chrysodioides*, are so heavily fertile that in age the sporangia appear to cover the whole leaf surface, but a careful dissection shows that the stalks always arise on the arcuate cross-veins and never from the leaf tissue between the veins.

In the Trinidad specimens and in most of those from British Guiana the sporangium wall is conspicuously setose. This is not true for most of the Brazilian material. However, this variation is not found to be correlated with other differences, and we regard the entire series of specimens as conspecific.

The genus Leptochilus Kaulf.²¹ is at present restricted by Ching and Christensen to a small group of Old World species considered to be of polypodioid rather than dryopteroid affinity. Most of the species formerly included in Leptochilus they place in Bolbitis Schott.²² Within the latter polymorphic genus, as represented in tropical America, the present species is quite isolated by reason of its entirely meniscioid venation. None of the other American species have this venation, although an approach is found in several Old World species, notably in B. subcrenata (Hook & Grev.) Ching, of India and Ceylon. In that the venation is sometimes entirely meniscioid, although commonly the basal areole bears more than one excurrent venule. In other respects, however, B. subcrenata is widely different from our plant. The sterile blades of B. macrophylla resemble very strongly those of Dryopteris chrysodioides, but may be distinguished by their glabrous rather than hirsutulous rachises and their glabrous leaf tissue.

²¹ Enum. Fil. 147. 1824.

²² Gen. Fil. pl. 14. 1834.

Bolbitis macrophylla is rather widely distributed, and we have examined the following specimens:

TRINIDAD: L'Orange Road, Hombersley 226 (US). Brazil, Britton, Britton, & Freeman 2142 (US). Without specific locality, Bot. Gard. Herb. 1584 (US); Fendler 88, type of Acrostichum Fendleri (US, Y).

TOBAGO: Between Roxborough and Parlatuvier, Broadway 4904 (US). BRITISH GUIANA: Barina River, Jenman (Y). Demerara River, Jenman (Y). Potaro River, Jenman 1449 (K). Without special locality, Jenman 2072 (K); Appun 732 (K).

FRENCH GUIANA: Acarouany (or Karouany), Sagot 1396 (B, K). Menonicia, Leprieur 70 (US).

Brazil: Serra do Mar, near Ilhéos, Bahia, Martius 363, type coll. (K, Y); Blanchet 2228 (K), 2477 (K). Bahia, Luschnath 82 (B). Para, Pételot (F). Tanaii, Spruce 32** (K). Sa do Mar, São Paulo, Wacket 211 (Y). Without special locality, Riedel 1292b (B); Riedel s. n. (C); Riedel 59, form with simple blades (US); Glocker s. n. (US).

PERU: Pongo de Manseriche, Loreto, Mexía 6202 (US).

VENEZUELA: Base of Mt. Cocui, Spruce 3030 (K).

MENISCIUM OPACUM Baker, Journ. Bot. Brit. & For. 15: 166. 1877.

As stated in the introduction this species, properly known as D. Christii C. Chr., belongs to the subgenus Stigmatopteris.

Meniscium salicifolium Presl, ex Ettingsh. in Denkschr. Akad. Wiss. Math. Naturw. (Wien) 23: 93. 1864; Ettingsh. Farnkr. Jetzw. 169. pl. 132, figs. 2, 7. 1865 (non Wall. ex Hook. 1854).

Described from Brazil on characters of venation only. We are unable to identify the figure definitely, though it suggests *Dryopteris Salzmanni*. The plant is utterly different from the Old World salicifolium of Wallich, under which it is cited in the Index Londinensis.

United States National Museum, Washington, D. C.

The Taxonomy of a Community of Blue-Green Algae in a Minnesota Pond

HELEN FOOT BUELL (WITH TWELVE FIGURES)

In a previous paper (Buell, 1938) the author described a fresh-water community of blue-green algae in Minnesota. In its early stages it is benthic in ooze in water 10 to 20 feet deep. Later it floats to the surface, buoyed up by gases liberated within the mass during photosynthesis.

This community is a globular mass whose outer portion is a thin, compact tegument composed almost exclusively of species of Oscillatoriaceae. The trichomes are arranged with their long axes parallel to the vertical axis of the mass. This tegument encloses a soft, oozy portion, forming the bulk of the mass. In this ooze are found chiefly unicellular pseudo-vacuolate Cyanophyceae.

The present paper is devoted to the Cyanophycean members of this community. Detailed discussions are given only of those forms believed to be new to science or which are otherwise significant.

METHODS

In the field small pieces of material were removed from different parts of the mass, in order to determine regional distribution of forms, and were preserved immediately in 3–4 per cent commercial formalin. Observations were also made on living material in order to offset any artifacts produced by the action of the preservative. The drawings were made from glycerine or glycerine gelatine mounts. Most of the figures were drawn to scale according to Tilden's (1934) method, and, with two exceptions, are reproduced at a magnification of 1000.

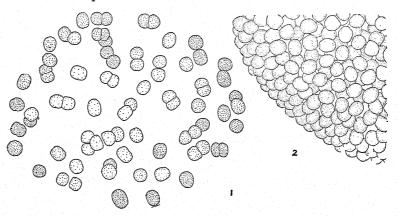
The type specimens have been deposited in the phycological laboratory of the botany department at the University of Minnesota.

CHROOCOCCACEAE

Microcystis pulverea (Wood) Migula (fig. 1) is found rarely in the interior portion of most communities. The size of the cells is from $1.6-2.0 \times 1.6-2.6\mu$, with an average of $1.7\times 2.0\mu$. Authors (Wolle, 1887; Lemmermann, 1907; Forti, 1907; Tilden, 1910; Smith, 1920; Crow, 1923; Geitler, 1925, 1932) have described the cells of M. pulverea as ranging in size from 2 to 3μ . Lemmermann (1907), in establishing M. incerta, gave its size as $1-1.5\mu$, while Smith (1920) places the size at $1-2\mu$. Smith also states that since the difference between M. pulverea and M. incerta is "mainly one of

size it might be better to consider M. incerta a variety of M. pulverea." Crow (1923), following Smith's suggestion, says, "it therefore seems that the essential difference between the two forms is one of size and as it is not customary to establish species on this character alone we have regarded M. incerta as a variety of M. pulverea." Geitler accepts Crow's decision. However, in view of the fact that the sizes for species and variety are continuous, i.e., $1-2\mu$ and $2-3\mu$, and also in view of the fact that the cells described here are intermediate in size between them, it seems better to consider M. incerta as synonymous with M. pulverea, the size range for the species then being $1-3\mu$.

Microcystis spp. In the interior of the community the dominant algae are pseudo-vacuolate species of Microcystis. These become very abundant



Figs. 1-2. Fig. 1. Microcystis pulverea (Wood) Migula. ×1000. Fig. 2. Coelomoron regularis H. F. Buell spec. nov. One fourth of colony, surface view. ×1000.

during the hot weather of August; a single microscope mount may show hundreds of colonies. Crow (1923) says, "whenever abundant material occurs the precise limits of the different species become impossible to define." The Minnesota material illustrates this fact, intergrading colony forms occurring between all the species present. The following species are definitely present: M. protocystis Crow, M. viridis (A. Braun) Lemm., M. flos-aquae (Wittr.) Kirchn., M. marginata (Menegh.) Kütz., and M. aeruginosa Kütz. These species are listed in the order of their abundance. All are present in algal masses throughout the season, but M. protocystis increases enormously in numbers during August. The species is described by Crow (1923) as having irregular, often diffuse colonies, with the plants generally dissociated. In this Minnesota material the colonies are very diffuse and the plants widely scattered. The abundance of this alga and its diffuse state are especially interesting in view of Naumann's (1925) in-

vestigations on the form of the colony (M. aeruginosa) in relation to water movement. He concluded that large colonies, in part clathrate, with diffluent gelatine and scattered cells, develop in quiet water; while small, compact colonies develop in moving water. In the interior of these algal masses, where there is a minimum of water movement, the most common species is that having the maximum degree of dissociation.

Coelomoron gen nov. Tegumentum prope aut in totum invisibile, achromaticum, tenue, diffluente; coloniae microscopicae, globosae, ellipticae, aut ovatae, principio solidae, tum denique cavae; plantae coloniarum maturarum peripherice ordinatae in strato 2–3 cellularum; cellularum divisio primo in omnem directionem, tum denique tantum in angulis dextris ad superficiem coloniae.

Tegument almost or entirely invisible, colorless, thin, diffluent; colonies microscopic, spherical, elliptical, or ovoid, at first solid, later hollow; plants of mature colonies peripherally arranged in a layer of 2–3 cells; cell division at first in all directions, later only at right angles to the surface of the colony.

The genus differs from *Microcystis* in that a hollow colony is formed at maturity, and from *Coelosphaerium* in that the plants are arranged in a layer 2-3 cells thick, instead of in a single layer.

Coelomoron regularis spec. nov. (figs. 2 & 3). Tegumento prope aut in totum invisibili, achromatico, tenui, diffluenti; coloniis microscopicis, globosis, ellipticis, aut ovatis; coloniis immaturis usque ad 30μ crassis, solidis; coloniis

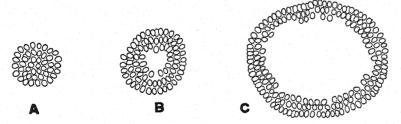


Fig. 3. Coelomoron regularis H. F. Buell spec. nov. Optical cross sections. A. Young colony. B. Older colony. C. Mature colony. Camera lucida drawings. ×375.

maturis cavis; plantis confertis compositis, peripherice ordinatis in strato 2–3 cellularum, globosis aut ovatis, saepe leviter planis propter mutuam pressuram praesertim in faciebus in angulis dextris ad superficiem coloniae; protoplasmate laete aeruginoso, sine pseudoracuolis. Tegumento $2-4\mu$ crasso extrinsecus plantam. Coloniis usque ad 250μ , plerumque minus quam 100μ . Plantis $3-5\mu$ diametro.

Tegument almost or entirely invisible, colorless, thin, diffluent; colonies microscopic, spherical, elliptical, or ovoid; immature colonies up to 30μ in

diameter, solid; mature colonies hollow; plants crowded, peripherally arranged in a layer of 2–3 cells, spherical or ovoid, often slightly flattened because of mutual pressure especially on the faces at right angles to the surface of the colony; protoplasm bright blue-green, without pseudo-vacuoles. Tegument 2–4 μ thick outside of the plants. Colonies up to 250 μ , usually less than 100 μ in diameter. Plants 3–5 μ in diameter.

Type locality: Mud in interior of algal mass, 10-20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

This alga is found occasionally as a rare to common constituent of the interior portion of the community. The colonies are remarkable for their "neat" compactness, and for the regular arrangement of the plants (Fig. 2), unlike anything found in *Microcystis*. The optical cross sections (Fig. 3) show the angularity of the cells, as well as successive stages in the formation of the interior cavity of the colony. The interior of the colony sometimes appears quite transparent and homogeneous; more often fine granulations are present, probably bacterial in nature.

Coelosphaerium Nägelianum Ung. is present in the interior of the community rarely or commonly. The development of the species is favored by the same conditions as favor the development of pseudo-vacuolate species of *Microcystis*.

Merismopedia species present in the interior core include M. convoluta Bréb., which is present rarely or commonly in practically all masses, M. elegans A. Braun and M. glauca (Ehrenb.) Näg., which are occasionally present, and M. punctata Meyen, which is rare to very abundant.

Merismopedia punctata¹ (fig. 4) is of special interest. It is one of those species (see Geitler, 1932) in which the long axes of the cells are parallel with the plane of the colony, instead of being at right angles to it. The diameter of the cells which is at right angles to the surface of the colony is approximately the same as the shorter diameter seen in surface view—about 2μ (fig. 4 E). This means that the plants are attached to each other by a very small area, as compared with the condition in such species as M. convoluta. Hence the plants break apart readily and the colonies

¹ As far as I have found, all references to this plant, beginning with Kützing (1849, p. 472), which state the place of publication, give it as Wiegmann's Archiv für Naturgeschichte 5: 67, 1839. Earlier, however, Meyen (1829, pl. 43, fig. 36) had figured the plant but did not name it. In 1839 in his *Pflanzen-Physiologie* (pp. 440-441) he named and described the plant. During the same year in Wiegmann's Archiv für Naturgeschichte he referred to his naming and description of 1839, in his physiology, as having occurred prior to his brief comment in the Archiv. Hence, Pflanzen-Physiologie 3: 440, 1839 is the original place of publication of the species *Merismopedia punctata* Meyen.

never attain any great size. Colonies having as many as 128 plants are rare; 32 is the usual maximum.

In the Minnesota material the cells are much more variable in size than as given by most authors—i.e., $2.5-3.5\mu$ in diameter. The maximum range, including all stages of growth (see below), is $.8-2.6\times1.2-3.9\mu$. Even in the normal blue-green phase (fig. 4 A–D), the cells range in their greatest diameter from 1.8 to 3.9μ .

For the most part division and growth appear to be practically simultaneous in all plants of a colony, resulting in individuals of approximately

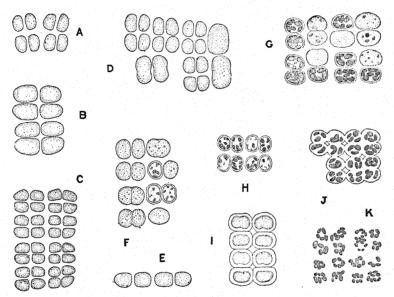


Fig. 4. Merismopedia punctata Meyen. A-D. Colonies showing arrangement and size of cells. E. Edge view of colony. F-K. Stages in vacuolation of colonies. $\times 2000$.

the same size (fig. 4 A–C). Irregularities in size sometimes occur where "division rhythm" is lacking. In a few collections many colonies are found in which this rhythm is absent, and those cells in which the impulse toward division is absent continue to increase in bulk practically in unison with other pairs or groups of cells (fig. 4 D). Except for such comparatively rare instances, the colonies of this species show remarkably regular cell arrangement.

In normal vegetative condition the protoplasts are gray to pale bluegreen, as Smith (1920) states. However, under some conditions the color and appearance change. Viewed under low and high powers of the microscope, each cell appears as a bright, rose-violet vacuole surrounded by a hyaline blue sheath (fig. 4 I). Under oil immersion (fig. 4 H), however, the vacuolate portion appears to consist of large, bright, dark rose bodies (Klincksieck and Valette, 1908, colors 6-7, 27-28), imbedded in a strawcolored matrix (colors 103, 128). The exterior portion seems narrower than under high power, but retains its hyaline, blue, cartilaginous appearance. Frequently in one colony (fig. 4 F, G) there may be found stages in the development of the vacuolate condition from the normal bluish-green cells, showing conclusively that the former is but a phase of the latter. The homogeneously granular cell contents become coarsely granular; the background becomes faintly straw-colored; and the granules seem to aggregate in small groups, at first indistinct in outline. The exterior portion appears gradually, at first wider than later, and indistinctly limited within. Eventually all the cells in a colony become vacuolated (fig. 4 H). When conditions are such that these vacuolations form, the growth of the cells is decreased, but division continues. In consequence, the average size of these rose-colored cells is smaller than that of the blue-green cells, about $1.5 \times 2\mu$, as compared with $1.9 \times 2.5\mu$. Later the outline of the plants disappears, except around the outside of the colony (fig. 4 J), and still later this also disappears, and the colony consists merely of groups of rosecolored granules (fig. 4 K).

The nature and cause of the vacuolation of these cells is doubtful. The color, while resembling that found in blue-green algae supposed to possess phycoerythrin, has less purple in it, and the normal vegetative cells have none of the gray-violet tint characteristic of these algae, nor is there ever any evidence of pigment diffusing into the surrounding water. Neither have the vacuolations the familiar appearance characteristic of the pseudovacuoles found in such planktonic forms as Microcystis flos-aquae; and, in addition, while masses of the latter species appear pale yellow-green or cream-color, masses of Merismopedia punctata are bright rose-purple. There seems to be no doubt, however, that these vacuolations, like the pseudo-vacuoles of Microcystis (Van Goor, 1925) contribute to the buoyancy of the colony, as in mounts of the material the blue-green colonies sink to the slide, while the vacuolate colonies float at the upper surface of the medium. And, although the appearance of the plants is quite unlike that of pseudo-vacuolate planktonic algae, it seems probable that the vacuoles are physiologically similar, since they respond similarly to treatment with acid (Van Goor, op. cit.). By treating material of M. punctata with acid (a few drops of HCl or acetic acid added at the edge of the cover glass), the vacuolations are made to disappear, and cells such as those shown in figure 4 H assume the color and appearance of the blue-green stage; at the same time the colonies sink and rest on the slide.

That the vacuolation of these algae is a stage in the process of disintegration seems likely. This conclusion is reached in view of the retarding or cessation of growth in vacuolate colonies, the ultimate breaking up of the plants into separate granules, and the fact that in the laboratory they form a flocculent purple scum on the surface of material which has been standing some days in a warm room and which is well advanced in disintegration. The conditions causing vacuolation are peculiar to the individual community, since on the same day one collection may show chiefly non-vacuolate and another chiefly vacuolate colonies of M. punctata.

With regard to the position of *M. punctata* within the genus, it should be noted that there is a sharp distinction between this species and *M. convoluta* in respect to the direction of elongation of the cells. If we accept as valid Troitzkaia's (1922) separation of *Coccopedia* from *Holopedia* on the basis of the former having round cells, while the latter has cells elongated at right angles to the plane of the colony, then it would seem equally proper to separate into a new genus *M. punctata* and related species which have the long axes of the cells parallel with the plane of the colony. On the other hand, in view of the gradations that exist between the genera of the plate-forming Cyanophyceae (*Merismopedia*, *Coccopedia*, *Holopedia*), there is the opinion of Ryppowa (1925) to consider. He places these groups as subgenera of the single genus *Merismopedia*. It would thus seem reasonable to separate into a subgenus those members of the genus *Merismopedia* (as generally understood) which have their long axes parallel to the plane of the colony.

Next, the synonymy given by Geitler (1932) is to be considered. He says: "Inc. M. paludosa Bennet, Journ. R. Micr. Soc. P. 4, Taf. 1, Fig. 1, 1886?—M. thermalis Kützing, Tab. phyc. 5, Taf. 38.—M. convoluta f. minor Wille, Alg. Zentrales, Sven Hedin, 1922.—M. glauca var. fontinalis Hansg., Prodr. Alg. Fl. Böhmen, 2, S. 141, 1892."

After examination of Bennett's (1886) article, it appears to me impossible to include M. paludosa with M. punctata: the cells, according to Bennett, have a diameter of 12.5μ ; Bennett himself questioned whether or not the plant belonged to the genus Merismopedia; and his figure indicates that he probably had a species of Tetrapedia.

Kützing's (1849) M. thermalis, judging from its size and general description, may perhaps be synonymous with M. punctata.

It seems doubtful if M. convoluta f. minor Wille (1922) can be included with M. punctata as the size is incorrect. Wille says: "Long. cell $4-5\mu$, lat. $2-3\mu$." Even in the abnormally large cells in which division has failed to occur (see above) the largest size of M. punctata found in my material

is 3.9μ . Wille's figure represents plants which strongly resemble M. convoluta.

Whether or not M. glauca var. fontinalis Hansgirg (1892) should be included with M. punctata it is difficult to determine from the description.

The following paragraphs take up the question of synonymy as it appears to me.

In its vacuolate stage M. punctata agrees well with Wittrock's (1889) description of M. chondroidea Wittr. in the matter of color, granulation, wall characters, size of cells, and character of the colony. Geitler (1925) separates M. chondroidea from M. punctata on the basis of the presence of vacuoles in M. chondroidea, although he says that it probably does not belong to the genus Merismopedia. Geitler (1932) says that M. chondroidea is an aberrant form which is best removed from the genus.

A specimen from Wittrock's material³ has been examined and compared with the Minnesota material. Most of Wittrock's material consists of blue-green cells which appear to be typical *M. punctata*. Only a few colonies are present in which some or all of the cells are vacuolate. These, however, appear to be quite typical of the vacuolate phases found in the Minnesota collections of *M. punctata*. In the latter material vacuolate cells, when soaked up after having been dried, usually are blue-green in color, only occasional cells retaining their vacuolations and rose color. In view of these facts, I am convinced that the alga which Wittrock named *Merismopedia chondroidea* is a phase of *M. punctata* Meyen.

Closely similar to M. punctata is another species of Merismopedia-M. tenuissima Lemm. Lemmermann (1898) described it as having cells $1.3-2\mu$ in size, pale blue-green, closely compressed into families of 16 cells. Smith (1920) and Geitler (1932) state that the number of cells in a colony is 16 to 100. Geitler separates this species from M. punctata on the basis of cell size, M. tenuissima having cells $1.3-2\mu$ in diameter, while M. punctata has cells $2.5-3.5\mu$ in diameter. Nevertheless, in the Minnesota material the range of cell sizes— $1.2-3.9\mu$ —includes the sizes given by Geitler for both M. punctata and M. tenuissima. Smith (1920) distinguishes between these two species on the basis of the distance between cells, M. tenuissima having the cells closely compressed and M. punctata having the cells "some distance from one another." His figures agree with this

³ Wittrock and Nordstedt, no. 200, kindly supplied by the late Dr. M. A. Howe of the New York Botanical Garden.

 $^{^2}$ "M. cellulis cytioplasmate purpurascente-violaceo, granulis, sulphuraceis nullis, membrana crassa quasi chondroidea; diametro cellularum sphaericarum 2, 4-2, 6μ ; coenobiis 4 vel 8-(rarius 2, 12, 16) cellularibus, in glomerulos saturate violaceos, forma indefinita, in superficie aquae demum natantes coacervatos."

statement. In a later publication, however, Smith (1924) figures a colony of M. tenuissima having cells farther apart than those shown in his 1920 figure of M. punctata. And Fritsch (1912) figures M. tenuissima with cells both close together and wide apart. In the Minnesota material some colonies are found which agree with Smith's (1920) figure of M. tenuissima, others which agree with his figure of M. punctata, and many which are intermediate. Hence, it appears probable that M. tenuissima and M. punctata are synonymous.

Lemmermann (1900) described another species, M. Marssonii Lemm., having many similarities with M. tenuissima, but distinguished from it by the presence of gas vacuoles, which, however, disappeared on treatment with acids. In view of what has been said with regard to the relation between the blue-green phase of M. punctata and its vacuolate stage, which has been described as M. chondroidea, there seems little doubt that Lemmermann's M. Marssonii is the vacuolate phase of his M. tenuissima. If this be true, it then seems that M. Marssonii Lemm. and M. punctata Meyen are synonymous.

Bachmann (1920) described still another vacuolate species, M. Trolleri. The plants formed a dull violet mass which was driven on to the beach by the wind. The colonies were 8-celled, sometimes 16-celled. The cells were $2-3\mu$ in diameter, each cell possessing a thick sheath. The contents consisted of wine-red granules, "die oft in die Hülle herausquellen." Except that the size of these plants is a trifle larger than the average size of the vacuolate plants of M. punctata, Bachmann's description and figures fit very well the vacuolate phase of M. punctata. The expression "Kügelchen, die oft in Hülle herausquellen" appears to be descriptive of such a stage as is pictured in this paper in figure 5 J, K, when disintegration of the plants is well advanced. While in the Minnesota material the algae do not as a rule occur in macroscopic masses, they do occasionally; in laboratory cultures quantities of M. punctata at times form a dirty violet scum at the water surface; and in the stagnant arm of a lake in western Wisconsin I have found the vacuolate phase of M. punctata producing just such masses as Bachmann describes. In view of these facts, it appears probable that M. Trolleri is the same as M. punctata.

Holopedia geminata Lagerh. is present in the interior of communities occasionally, sometimes common, especially when in company with Merismopedia convoluta.

Holopedia pulchella spec. nov. (fig. 5). Coloniis minutis; plantis irregulariter dispositis, confertis compositis, polygonie planis; protoplasmate laete aeruginoso; plantis $2.5-4.8\mu$ diametro (facies coloniae), $3.4-5.3\mu$ longitudine (extremitas coloniae).

Colonies small; plants irregularly placed, closely compressed, polygonally flattened; protoplast bright blue-green; plants $2.5-4.8\mu$ in diameter) surface of colony,) $3.4-5.3\mu$ long (edge of colony).

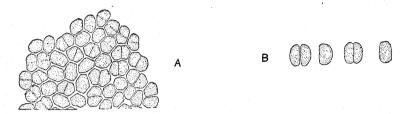


Fig. 5. Holopedia pulchella H. F. Buell spec. nov. A. Portion of surface of colony. B. Longitudinal views of cells. ×1000.

Type locality: Mud in interior of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: Holopedia pulchella is rare, or occasionally common, in the interior portion of the community, usually in company with H. geminata and Merismopedia convoluta.

Remarks: H. pulchella differs from the most closely related species, H. sabulicola Lagerheim, in four particulars: 1) colonies unattached; 2) colonies living in fresh water; 3) plants crowded; 4) plants smaller.

Lagerheim (1883) found *H. sabulicola* in the Baltic Sea, attached to grains of sand along with species of *Merismopedia*. The Minnesota material has been compared with a fragment from Lagerheim's specimen.⁴ The plants are similar in general appearance, except that in *H. pulchella* they are more crowded and angular, and are considerably smaller than in

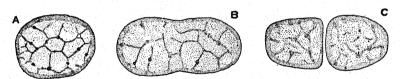


Fig. 6. Synechococcus aeruginosus Nägeli. ×1000.

H. sabulicola. The latter is described by Lagerheim as having cells 6μ long, and in his dried material they have been found to be $6-6.8\mu$ in length.

Synechococcus aeruginosus Nägeli (Fig. 6) is rare or common in the interior portion of most masses. The plants are from 13 to 16μ in diameter. The color is a pale greenish-gray, and the general appearance is like that

⁴ Wittrock, Nordstedt, and Lagerheim no. 1549, kindly furnished by the late Dr. M. A. Howe,

shown by Geitler (1932). The pigments, however, instead of being peripheral, seem to be in the interior of the cell, where they are confined to anastomosing strands. At intervals in the pigmented strands the granular substance is aggregated into larger masses which stand out brightly from the rest of the cell substance. The pronounced differentiation of the protoplasm into pigmented and unpigmented areas, and particularly the interior pigmented strands, is distinctive. It is true that Chodat (1896) found a pigmented central network in Chroococcus turgidus (Kütz.) Näg., and Crow (1922) refers to Chodat's work and also speaks of "shining globules of pigment within the cell" of some species of Chroococcus. While their words might seem to be in some measure descriptive of Synechococcus aeruginosus, nevertheless, as far as I have observed, and as far as available figures indicate, the appearance of the protoplast of Chroococcus turgidus is quite unlike that of Synechococcus aerguinosus. Indeed the distribution of pigments in the latter plant is much more suggestive of that in the red alga Porphyridium (Geitler, 1924) with its stellate, central chromatophore with strands reaching out to the periphery of the cell.

OSCILLATORIACEAE

Spirulina aeruginea spec. nov. (Section Arthrospira Geitler) (fig. 7). Strato viride-nigro; trichomatibus in spiras laxas regulares, vertes ab latere dextro ad latus sinistrum, apicibus gradatim attenuatis, ad dissepimenta haud constrictis; dissepimentis plerumque distinctis, interdum granulatis; cellulis diametro brevioribus cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta crasse granulato, laete aeruginoso; spiris $9.5-18\mu$ crassis, $14-24\mu$ inter versationes; cellulis $3.9-5.7\times 3.5-5\mu$.

Plant mass greenish black; trichomes in loose regular spirals, turning from right to left,⁵ gradually tapered at the apex, not constricted at the transverse



Fig. 7. Spirulina aeruginea H. F. Buell spec. nov. ×1000.

septa; transverse septa usually distinct, sometimes granulated; cells shorter than their diameter; apical cell usually longer than the diameter; protoplasm finely granular, at the transverse septa sometimes coarsely granulated, bright

⁵ In speaking of the direction of the spiral, the reference is to the direction as seen under the microscope, where of course the apparent direction is the reverse of the actual.

blue-green; spirals 9.5–18 μ broad, 14–24 μ between turnings; cells 3.9–5.7 \times 3.5–5 μ .

Type locality: Outer layers of Cyanophycean algal mass, 10-20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: Spirulina aeruginea is one of the characteristic and distinctive members of the community. With its allied species, S. amethystina H. F. Buell, and species of Oscillatoria, it forms the outer layers of the mass. During the summers of 1929 and 1930, S. aeruginea was more abundant than S. amethystina until the latter part of the season. Throughout the season of 1931, when beginning early in the summer the temperatures were unusually high, S. aeruginea was much less abundant than S. amethystina.

Remarks: Spirulina aeruginea is distinguished from S. Jenneri (Hassall) Kützing⁷ in three particulars: 1) the diameter of the trichome—3.9-5.7 μ —is somewhat less than in S. Jenneri, whose diameter is given as 5-8 μ ; 2) the extremity of the trichome tapers, while the trichome of S. Jenneri is untapered; 3) the spiral has a clockwise direction, while in S. Jenneri it has a counter-clockwise direction.

With regard to the direction of spiraling in the genus *Spirulina*, there is little information in the literature. Many of the earlier published figures do not indicate a spiral. No authors, as far as I know, state whether or not they consider the direction of spiraling constant in the species they describe. Geitler (1925) says that the direction of spiraling should be used as a diagnostic character, indicating that he considers it constant. In most of the published figures of *S. Jenneri*, including the widely copied drawing by Gomont (1892), the plant is drawn as if the entire body of the trichome lay in a single plane. As far as I have been able to discover, the only delineators who have indicated the direction of the spiral are Hassall (1845), Wolle (1887), Crow (1924), Frémy (1930) and Moore.⁸ All of these

⁶ Klincksieck and Valette (1908) colors 336, 342.

⁷ The specific name of this plant is variously credited—rarely to Hassall, generally either to Kützing or to Stizenberger. The first use of the name, however, appears to have been by Hassall (1845) in *Spirillum Jenneri*. Kützing (1846, 1849) used the name *Spirulina Jenneri* Kützing. Stizenberger (1852) placed Hassall's plant in his new genus *Arthrospira*. Gomont (1892), the universally accepted authority on the Oscillatoriaceae, gives the name *Arthrospira Jenneri* Stizenberger, but in his list of synonyms gives *Spirillum Jenneri* Hassall and *Spirulina Jenneri* Kützing. Hence if the genus *Arthrospira* is retained, the name of the species is *Arthrospira Jenneri* (Hassall) Stizenberger; while if it is returned to the genus *Spirulina*, the name is *Spirulina Jenneri* (Hassall) Kützing.

⁸ Moore, Marjorie Forbes—Department of Botany, University of Minnesota, unpublished observations.

indicate a counter-clockwise, or left to right, spiral. Likewise I have found in collections of bottom sand from the littoral region (10–20 cm.) in Lake of the Isles Lagoon typical S. Jenneri having counter-clockwise spirals. Consequently there is little doubt that a counter-clockwise direction of spiraling is characteristic of S. Jenneri. A clockwise direction of spiraling is definitely characteristic of S. aeruginea.

Spirulina amethystina spec. nov. (Section Arthrospira Geitler) (fig. 8). Strato levi nigro aut rubro; trichomatibus in spiras laxas regulares, vertes ab latere dextro ad latus sinistrum, apicibus gradatim attenuatis, ad dissepimenta haud constrictis; dissepimentis plerumque distinctis, interdum granulatis; cellulis diametro brevioribus; cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta interdum crasse granulato, viride-cinereo aut violaceo; spiris $9.5-18\mu$ crassis, $14-24\mu$ inter versationes; cellulis $3.9-5.7\times3.5-5\mu$.

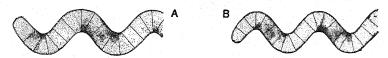


Fig. 8. Spirulina amethystina H. F. Buell spec. nov. ×1000.

Plant mass soft black or red; trichomes in loose regular spirals, turning from right to left,⁹ gradually tapered at the apex, not constricted at the transverse septa; transverse septa usually distinct, sometimes granulated; cells shorter than their diameter; apical cell usually longer than the diameter; protoplasm finely granular, at the transverse septa sometimes coarsely granulated, grayish green to violet;¹⁰ spirals $9.5-18\mu$ broad, $14-24\mu$ between turnings, cells $3.9-5.7\times3.5-5\mu$.

Type locality: Outer layers of Cyanophycean algal mass, 10-20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: Spirulina amethystina is one of the dominant members of the association which forms the outer layer of the mass. It is most abundant during extremely hot weather.

Remarks: This species is distinguished from *S. aeruginea* by its gray to violet color, instead of a typical blue-green color. While in the grayer phase of pigmentation of *S. amethystina* the purple tint is not noticeable, and while there are indistinguishable gradations from green-gray to distinct purple or violet, nevertheless there is no gradation in color between the green-gray of *S. amethystina* and the bright blue-green of *S. aeruginea*.

⁹ In speaking of the direction of the spiral, the reference is to the direction as seen under the microscope.

¹⁰ Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

The difference in color is striking in cases where trichomes of the two species twine about one another. It is probable that the purple color of S. amethystina is due to the presence of phycoerythrin, and that this pigment is entirely lacking in S. aeruginea. In view of this probability, and in view of the increasing tendency (Tilden, 1928) to consider pigmentation in the algae as a fundamental, elemental character of the organism, it seems desirable to consider S. amethystina as a distinct species.

With regard to the pigmentation of S. amethystina, one feature is of interest in connection with the theory advanced by Crow (1922, 1928) that the trichome of the Oscillatoriaceae is homologous with the single cell of the Chroococcaceae. While there is a wide variation in color from trichome to trichome, the color is constant within the individual trichome throughout its entire length, however great. There are also other indications that the trichome is the unit of structure in both S. amethystina and S. aeruginea; there is practical uniformity throughout the trichome in the degree of granulation of the protoplasm in both living and preserved plants; and there is considerable uniformity in the visibility of the transverse septa.

One point should be mentioned, however, which Crow (1928) makes in support of his theory of the homology between trichomes and unicellular plants. Of the genus Arthrospira he says: "The plants retain their hormogonial aspect throughout their life. The filaments of Arthrospira are, like those of Spirulina, amongst the shortest adult forms occurring in the family Oscillatoriaceae." Nevertheless, in S. amethystina and S. aeruginea the trichomes are fully as long as are those of accompanying species of Oscillatoria having a similar diameter. In any case, trichomes attaining a length of 1–2 mm., as are common in these two species of Spirulina, can hardly be said to have a "hormogonial aspect."

Species of Oscillatoria present in the exterior layers of the community are O. geminata Menegh., O. amphibia Agardh, O. limosa Agardh, O. Mougeotii Kütz., O. tenuis Agardh, O. princeps Vaucher, forma maxima (Kütz.) Rabenh. and forma tenuior Rabenh., O. terebriformis Agardh, O. formosa Bory, O. Okeni Agardh, and O. chalybea Mertens. All of these, except the last, are present in variable numbers, being rare to common. O. chalybea, however, is always present in considerable amount, and in masses which are blue-green or blackish-green in color, it is generally the dominant species in the outer layers. In addition there are present the following forms which are believed to be new to science.

Oscillatoria amethystina. spec. nov. (fig. 9). Strato levi nigro aut rubro; trichomatibus rectis, flexilibus, ad dissepimenta plus minusve constrictis, gradatim attenuatis ad longinquitatem ab apiculo; apiculo uncinato aut arcu-

ato; cellula apicali obtuso haud capitata, haud calyptrata; cellulis subquadratis vel brevioribus; cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, ad dissepimenta plus minusve crasse granulato, viridecinereo aut violaceo; cellulis $3.5-5\times2-3.5\mu$.

Plant mass soft black to red; trichomes straight, flexuous, more or less constricted at the transverse septa, gradually tapering for a long distance from the apex; apex hooked or curved; apical cell rounded, not capitate, not calyptrate; cells subquadrate or shorter; apical cell usually longer than the diameter; protoplast finely granular, more or less coarsely granulated at the transverse septa, greenish-gray to violet; 11 cells $3.5-5\times2-3.5\mu$.

Type locality: Outer layers of Cyanophycean algal mass, 10-20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.



Fig. 9. Oscillatoria amethystina H. F. Buell spec. nov. A. Terminal and median portions of a trichome. B. Portion of old, disintegrating trichome. ×1000.

Occurrence: O. amethystina is rare or common in the exterior portions of masses throughout the season, but is most abundant during the hottest weather.

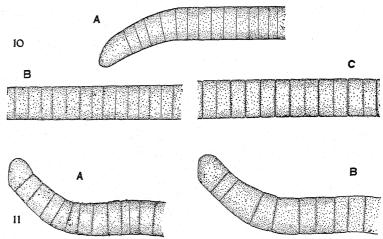
Remarks: This species appears to resemble most closely O. violacea (Wallr.) Hass., which has violet to blue-green trichomes, $4-4.5\mu$ in diameter. However, O. violacea is described as being sharply pointed at the apex, while O. amethystina does not taper to a sharp point, but is rounded at the apex. The appearance of the apical cell itself is much like that of the apical cell of O. formosa Bory, but in O. amethystina the tapering is greater and much more gradual. The trichome is usually much less constricted in the apical than in the median portion (fig. 9 A). The color of the plant is like that of Spirulina amethystina.

Oscillatoria Leavittae¹² spec. nov. (figs. 10, 11). Strato levi nigro aut rubro; trichomatibus rectis, ad dissepimenta plus minusve constrictis, gradatim attenuatis ad longinquitatem ab apiculo; apiculo uncinato aut arcuato; cellula apicali conica, plerumque leviter plana a parte superiore lateris convexi, haud capitata, haud calyptrata; cellulis diametro brevioribus, cellula apicali plerumque diametro longiore; protoplasmate tenui-granuloso, viridecinereo aut violaceo; cellulis $7.5-11.5\times3-7\mu$; cellulis apicalibus usque ad 11μ longis.

¹¹ Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

¹² This handsome species is named in honor of Miss Clara K. Leavitt, who discovered and first studied the community in which the plant grows.

Plant mass soft black or red; trichomes straight, more or less constricted at the transverse septa, gradually tapering for a long distance from the apex; apex hooked or curved; apical cell conical, usually flattened on the upper portion of the convex side, not capitate, not calyptrate; protoplast finely granular, greenish-gray to violet; cells $7.5-11.5\times3-7\mu$; apical cell up to 11μ long.



Figs. 10-11. Fig. 10. Oscillatoria Leavittae H. F. Buell spec. nov. A, B, C. Terminal, subterminal, and median portions respectively of one trichome. ×1000. Fig. 11. Oscillatoria Leavittae H. F. Buell spec. nov. Variations in apices of trichomes. ×1000.

Type locality: Outer layers of Cyanophycean algal mass, 10–20 feet of water, Lake of the Isles Lagoon, Minneapolis, Minn.

Occurrence: O. Leavittae is the dominant species in the exterior portion of reddish black or red masses. It is most abundant during the hottest weather of the summer.

Remarks: In the size of the trichomes O. Leavittae is similar to O. chalybea, whose trichomes are $8-13\mu$ in diameter. The gradual tapering characteristic of the new species also is similar to the condition usually described for O. chalybea. The latter species, 14 however, is described as having an obtuse apical cell, while O. Leavittae is characterized by a conical apical cell, peculiarly flattened on the upper portion of the convex side. Also the color is distinctive, there being as great a difference between the color of O. Leavittae and O. chalybea as there is between that of Spirulina amethystina and S. aeruginea (see above). The color is like that of Spirulina amethystina and Oscillatoria amethystina, and as in these two species, the color is most pronounced in the hottest weather.

¹³ Klincksieck and Valette (1908) colors 498, 517, 522, 533, 538, 548, 572.

¹⁴ Gomont (1892) says, "apicem versus breviter aut longe et sensim attenuata"; Frémy (1930) says, "longuement et insensiment atténués vers leurs extrémités." Both authors, however, figure a brief tapering.

The characters of the apical portion of the trichome are, of course, more or less variable, apparently depending on the amount of growth since breakage or formation of hormogones has occurred. Thus if a trichome has been recently broken, considerable growth must take place before the new apex becomes gradually tapered. Hence, for a time the apical cell will be more or less obtuse; but it soon acquires the characteristic flattening on the upper side of the curve (fig. 11).

In this plant, as in O. chalybea, there is usually a decided difference in long trichomes between the median and apical portions, The trichome is not merely wider in its median portion, it is also more strongly constricted (fig. 10 A, B, C), the protoplast is more coarsely granular, and the color is generally more pronounced. Apparently younger, actively growing portions of the trichome are greenish-gray, the red pigment being more abundant, or at least more evident, in older cells. The lack of uniformity shown by Oscillatoria amethystina, O. Leavittae, and O. chalybea as to constrictions, granulations and coloring of individual trichomes is in striking contrast with the condition shown by Spirulina aeruginea and S. amethystina (see above).

Species of *Anabaena* are present occasionally in the interior mud of the community. These include the pseudo-vacuolate species *A. planctonica* Brunnth, and *A. spiroides* Kleb., and two others, which in the absence of gonidia can not be identified.

Also Anabaena constricta (Szafer) Geitler (fig. 12) is present in prac-

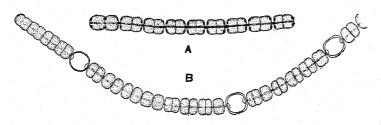


Fig. 12. Anabaena constricta (Szafer) Geitler. A. Filament without heterocysts. B. Filament with heterocysts. ×1000.

tically all communities, sometimes commonly. The vegetative cells are $5-7\times6-10\mu$. The colorless central portion of the filament has the appearance of a thread with beads strung on it. This "thread" is continuous from cell to cell, but it is very fragile and breaks readily; hence one rarely finds filaments composed of more than 15 or 20 cells. Geitler (1932) states that only two heterocysts (in one filament) have thus far been found (Koppe, 1924). Examination of hundreds of filaments in this material has disclosed one filament with three heterocysts (fig. 12 B). These

have a diameter of 5–6 μ and a length of 6–6.5 μ . Koppe reported a diameter of 5 μ .

SUMMARY

A description is given of the blue-green algae forming a freshwater community which develops in bottom ooze and later floats to the surface. One new genus is described—Coelomoron—a colonial member of the Chroococcaceae. New species described are Coelomoron regularis, Holopedia pulchella, Spirulina aeruginea, S. amethystina, Oscillatoria amethystina, and O. Leavittae, the last three of which are characterized in part by red pigmentation. Merismopedia chondroidea Wittr. is shown to be synonymous with M. punctata Meyen.

This work was done in the botanical laboratories of the University of Minnesota.

DEPARTMENT OF BOTANY,
NORTH CAROLINA STATE COLLEGE,
RALEIGH, N. C.

Literature cited

- Bachmann, H. 1920. Merismopedia Trolleri nov. spec. Zeits. Hydrologie (Revue d'Hydrologie) 1:350.
- Bennett, A. W. 1886. Fresh-water algae (including chlorophyllaceous Protophyta) of the English Lake District: with descriptions of twelve new species. Jour. Roy. Micr. Soc. II. 6: 1-15.
- Buell, H. F. 1938. A community of blue-green algae in a Minnesota pond. Ecology 19: 224-232.
- Chodat, R. 1896. Chroococcus turgidus. Nuova Notarisia. 98.
- Crow, W. B. 1922. A critical study of certain unicellular Cyanophyceae from the point of view of their evolution. New Phyt. 21: 81-102.
- ______. 1923. The taxonomy and variation of the genus *Microcystis* in Ceylon. New Phyt. 22: 59-68.
- ______. 1924. Variation and species in Cyanophyceae. Jour. Genetics 14: 391-424.
 - . 1928. The morphology of the filaments of Cyanophyceae. Ann. Protist. 1:19-36.
- Forti, A. 1907. Sylloge Myxophycearum. In, De Toni, J. B. Sylloge Algarum Omnium. Vol. 5.
- Frémy, P. 1930. Les Myxophycées de l'Afrique équatoriale française. Arch. de Botanique Caen, Vol. 3 (mém. 20).
- Fritsch, F. E. 1912. Freshwater algae. National Antarctic Expedition. Natural History 6: 1-60.
- Geitler, L. 1924. Ueber einige wenig bekannte Süsswasserorganismen mit roten oder blaugrünen Chromatophoren. Zugleich ein Beitrag zur Kenntnis pflanzlicher Chromatophoren. Rev. Alg. 1: 357-375.

- -. 1925. Cyanophyceae. In, A. Pascher. Die Süsswasser-Flora Deutschlands, Oesterreichs und der Schweiz. Heft 12.
- -. 1932. Cyanophyceae (Blaualgen). In, L. Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. Vol. 14.
- Gomont, M. M. 1892. Monographie des Oscillariées (Nostocacées Homocystées).
- Hansgirg, A. 1892. Prodromus der Algenflora von Böhmen, Vol. 2. Hassall, A. H. 1845. A history of the British freshwater algae.
- Klincksieck, P., and Th. Valette. 1908. Code des couleurs à l'usage des naturalistes, artistes, commerçants et industriels.
- Koppe, F. 1924. Die Schlammflora der ostholsteinischen Seen und des Bodensees. Arch. Hydrobiol. Planktonk. 14: 619-672.
- Kützing, F. T. 1846. Tabulae Phycologicae oder Abbildungen der Tange. Vol. 1. -. 1849. Species Algarum.
- Lagerheim, G. 1883. Bidrag till Sveriges algflora. Ofversigt Kongl. Vetenskaps-Akademiens Förhandlingar. No. 2. 37-38.
- Lemmermann, E. 1898. Beitrage zur Kenntniss der Planktonalgen. II. Beschreibung neuer Formen. Bot. Centralbl. 76: 150-156.
- -. 1900. Beiträge zur Kenntniss der Planktonalgen. III. Neue Schwebalgen aus der Umgegend von Berlin. Ber. Deutsch. Bot. Ges. 18: 24-32.
- -. 1907. Algen. (Schizophyceen, Flagellaten, Peridineen.) In Kryptogamenflora der Mark Brandenburg. Vol. 3.
- Meyen, F. J. E. 1829. Beobachtungen über einige niedere Algenformen. Nova Acta Acad. Caes. Leop.-Carol. 14: 769-778.
- -. 1839. Neues System der Pflanzen Physiologie. Vol. 3.
- -. 1839. Jahresbericht über die Resultate der Arbeiten in Felde der Physiologischen Botanik von dem Jahre 1838. Archiv Naturgeschichte $5^2: 1-152.$
- Naumann, E. 1925. Notizen zur experimentellen Morphologie des pflanzlichen Limnoplanktons. I-II. Bot. Notiser. 1925: 47-51.
- Ryppowa, H. 1925. Merismopedia (subgenus Pseudoholopedia) gigas (nov. subgen. nov. sp.). Acta Soc. Bot. Poloniae 3: 42-48. (Summary in Rev. Alg. 3: 267-268.)
- Smith, G. M. 1920. Phytoplankton of the inland lakes of Wisconsin. Part. 1. Myxophyceae, Phaeophyceae, Heterokonteae, and Chlorophyceae exclusive of the Desmidiaceae. Wisconsin Geol. and Nat. Hist. Survey. Bull. 57. Sci. Ser. 12.
- -. 1924. Ecology of the plankton algae in the Palisades Interstate Park, including the relation of control methods to fish culture. Roosevelt Wild Life Bulletin 2:96-195.
- Stizenberger, Dr. 1852. Spirulina und Arthrospira (nov. gen.). Hedwigia 1:32.
- Tilden, J. E. 1910. Minnesota Algae. I. The Myxophyceae of North America and adjacent regions including Central America, Greenland, Bermuda, the West Indies and Hawaii.
- -. 1928. Some hypotheses concerning the phylogeny of the algae. Am. Nat. 42: 137-155.
- -. 1934. Standardization of method for drawing algae for publication. Bot. Gaz. 95: 515-518.
- Troitskaia, I. V. 1922. A new genus of blue-green algae. Notulae Syst. Inst. Crypt. Hort. Bot. Petropolitani. 1: 129-131.

- Van Goor, A.-C.-J. 1925. Contribution à la physiologie des Cyanophycées. Sur les pseudo-vacuoles rouges et leur signification. Rev. Alg. 2: 19-38.
- Wille, N. 1922. Algen aus Zentralasien gesammelt von Dr. Sven Hedin. In, Southern Tibet. Discoveries in former times compared with my own researches in 1906-1908, by Sven Hedin. 6(3) Botany: 155-195.
- Wittrock, V., and O. Nordstedt. 1889. Algae aquae dulcis exsiccatae praecipue scandinavicae, quas adjectis algis marinis chlorophyllaceis et phycochromaceis. Fasciculus 21. Descriptiones systematice dispositae et index generalis fasciculorum 1–20.
- Wolle, F. 1887. Fresh-water algae of the United States.

The Cactaceae of Southern Utah

ELZADA U. CLOVER (WITH PLATES 15-19)

A field survey of the Cactaceae in a part of southern Utah yielded interesting material and new information regarding distribution of cacti. The work was sponsored by Mr. E. J. Marston of Colorado Springs, Colorado, who is interested in furthering a systematic and phytogeographic study of the family.

The author was accompanied and assisted by Miss Carol Davidson of Colorado Springs; and although the time (July 31 to August 15) was brief in which to cover so much territory, the results were gratifying. Many of the roads in the following counties were traversed: Grand, San Juan, Kane,

Washington, Iron, Garfield, Wayne, and Emory.

This territory is drained chiefly by the Green and Colorado Rivers and their tributaries. The Virgin River has its origin in western Kane County and flows through Washington County. Most of southern Utah belongs to the Plateau province as defined by Powell. The extreme southwestern portion is included in the Great Basin.

This part of Utah holds a special interest for the botanist because it is within the northern limits of the Lower Sonoran desert zone, although theoretically most of it should be northern desert. The flora has not been well studied because of the scarcity of population and lack of roads. Thousands of square miles of southeastern Utah are entirely unsettled and a pack train with a competent guide who knew the country well enough to find waterholes would be necessary for thorough exploration.

Clay and sandstone of the Jurassic and Triassic cover the major part of counties studied. The exposed rocks range from whitish-pink to deep red sandstone, and light to chocolate shales with outcrops of limestone.

The cacti extend their ranges more slowly than many plants, because they grow slowly and have no special modifications insuring seed dissemination. Without question, the ranges of many species have been limited by physiographic features; some cacti are found on one side of a mountain range and not on the other, although conditions appear to be practically the same on both sides. Where such barriers exist, distribution follows water courses. The canyons and cuts in the vicinity of Fruita have a more southern flora than one would expect, since the upland here belongs to the piñon zone. The lower altitude may have some influence, but it is thought that the Lower Sonoran flora follows the valleys since migration over the high plateaus is impossible.

Altitude has a decided effect on vegetation, the lowlands having a growing season two to three times as long as that of the high plateaus. The precipitation in general is greater at higher altitudes, although St. George with an altitude of only 2880 feet has a greater rainfall than Loa with an altitude of 7000 feet. Navajo Mountain, judging by the vegetation, receives an annual rainfall exceeding 20 inches; while the surrounding country has a very meager rainfall, and little or no vegetation in places as a result

Soil seems to be more of a limiting factor for some species than others. Echinomastus Johnsonii apparently needs calcareous soil. The Echinocerei also can be found on limestone ledges or on sand mixed with limestone without so much regard to altitude or moisture, but the caespitose form of Pediocactus and the western Coryphanthae are confined to the higher altitudes and show greater latitude in the matter of soil tolerance. The solitary form of Pediocactus grows at a lower altitude than the other but is found at its best under rather moist conditions, often close to streams or standing water. Several species of cacti in the vicinity of St. George have either abruptly reached the northern limit of their range or are limited by other factors than climatic. The lower altitude and correspondingly higher temperature in the extreme southwestern part of the state may account for the richness of the sub-tropical cactus flora.

It is possible that soil conditions may be at least partially responsible for northern limits of range. The Precambrian strata are exposed in this section and extend over the portions of Nevada, California and Arizona occupied by these same species. They are characterized by limestones which may have the same distribution as the characteristic plants of the region.

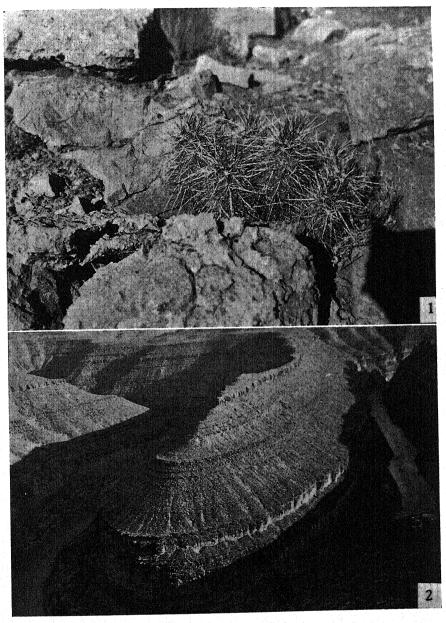
Catastrophes have played some part in retarding distribution. Opuntia polyacantha and Sclerocactus Whipplei can be found in fair abundance, north of Bluff, but the plants are mostly dead or dying probably from drought. An annual rainfall of three inches has been reported for Bluff. Farther east in the dust bowl region skeletons of numerous plants testify to the effect of changing conditions there. Flood waters in mountainous areas destroy species which may be migrating, and may on the contrary deposit plants or seeds which become established in a new territory.

It is interesting to note the variation within a species throughout a

Explanation of Plate 15

Fig. 1. Echinocereus Engelmannii reported to have white flowers. Growing on limestone near the San Juan River (fig. 2).

Fig. 2. The "Goosenecks," cut through shale and sandstone by the San Juan River, Mexican Hat, San Juan Co., Utah,



CLOVER: CACTACEAE

range of fifty to several hundred miles, particularly in a north and south direction. The change in form and character is often so gradual that it can scarcely be detected, but plants from the extremes of these ranges can often scarcely be recognized as belonging to the same species. Specific examples are *Opuntia fragilis* and *Opuntia polyacantha; Echinocereus Reichenbachii* and some of the opuntias growing farther east also vary greatly.

The family is generally thought of as young from the evolutionary standpoint in such aggressive genera as *Optunia*. There are, however, locally restricted types of no very obvious affinity that give the impression of being possibly ancient. Such a one is *Utahia Sileri*, which is very different from other cacti in the region and has a limited distribution. If this is the method of evolution, we are presented with the necessity of accounting for apparently continuous variation as the specific range is traversed, on the ground of successive cumulative changes in the same direction. Of course "place effect" may be of greater magnitude than seems likely. The seemingly continuous gradations afford magnificant material for genetic research bearing on the problem of climatic and habitat adaptation.

LIST OF SPECIES

Opuntia Ramosissima Engelm., Amer. Journ. Sci., Series 2, 14: 339. Specimens collected at Beaver Dam Wash, Washington Co. by a citizen of St. George (1870). This is an odd species of the subgenus *Cylindropuntia*, with no close relatives. Reported hitherto from southern Nevada, western Arizona, southeastern California and northwestern Sonora. Habitat: Dry desert flats.

OPUNTIA WHIPPLEI Engelm. & Bigelow, Proc. Amer. Acad. 3: 307. 1856. Kanab, and Johnson, Kane Co. (1883); Enterprise, St. George, Washington Co.; Santa Clara Valley, Iron Co. Reported elsewhere from northern New Mexico, Arizona and southwestern Colorado.

HABITAT: Sandy calcareous soil on south and west slopes, also on sandy flats, associated with Joshua trees, Ferocactus acanthodes, Echinomastus Johnsonii and Echinocerous Engelmannii at St. George, Washington Co.; on red sandstone in Kane Co.; on rocky slopes near Enterprise, Washington Co.

Opuntia acanthocarpa Engelm. & Bigelow, Proc. Amer. Acad. 3: 308. 1856. South of St. George, Washington Co. (1882). This species is probably most abundant in Arizona although it is found in California near the Nevada state line and the Colorado River; also common in Nevada.

HABITAT: Foothills or stony mesas, on limestone, sandstone and shale.

OPUNTIA ECHINOCARPA Engelm. & Bigelow, Proc. Amer. Acad. 3: 305. 1856. St. George, Washington Co. (1886); Kanab, Kane Co., Beaver Dam

1938]

Mts.; widespread in southern California and found in southern Nevada, northwestern Arizona and Sonora.

HABITAT: On mesas and slopes, limestone outcrops, sandstone and shale.

OPUNTIA BIGELOVII Engelm., Proc. Amer. Acad. 3: 307. 1856. South of St. George, Washington Co. (1890). This has previously been found in Nevada, Arizona, California, Lower California and Sonora.

HABITAT: In isolated colonies which are often miles apart; in sandy soil or in sand mixed with decomposed granite; in limestone outcrops usually on dry steep hillsides, south and west exposures.

OPUNTIA BASILARIS Engelm. & Bigelow, Proc. Amer. Acad. 3: 298. 1856. South of St. George in Joshua forest, Washington Co. (1887); Beaver Dam Mts.; present in northern Sonora, western Arizona, southern California and Nevada.

HABITAT: Calcareous soils on dry hillside; reported as growing also on river flood plains.

OPUNTIA AUREA Baxter, Journ. Cac. Succ. Soc. 5: (6). 1933. Between Kanab and Zion National Park, Kane Co. (1885) at an altitude of 6500 to 7000 ft.: reported also on both sides of the Arizona-Utah border near the Kaibab Indian Reservation; Cane Beds, Pipe Springs, between Zion Park and Carmel, Utah; west of the Kaibab Indian Reservation to the lower slope of the Sierras near Bishop, California. This is one of the Basilares recently described, differing from O. basiliaris by having joints in a chain instead of in a truly basilar form.

HABITAT: South of Zion National Park on a dry, steep, clay hillside, associated with Juniperus.

OPUNTIA BRACHYCLADA Griffiths, Proc. Biol. Soc. of Washington, 27: 25, 1914. In the Dixie National Forest between Veyo and Enterprise, Washington Co. (1888). This species was not recognized by Britton and Rose but has been taken up by Baxter in his report on California cacti as a distinct species of the Basilares. He collected the plant in Pine Canyon, Sheep Creek Canyon, Dead Man's Gulch, and Mescal Canyon all within fifteen miles. It has also been reported from above Big Bear Lake in the San Bernardino Mts.

HABITAT: West slope in sandy, calcareous soil. Only two clumps were found, but they were very characteristic.

OPUNTIA PHAEACANTHA Engelm., in Gray, Mem. Amer. Acad. 4: 52. 1849. LaSal, Grand Co.; Bluff, San Juan Co., Kanab, Kane Co. (1894), Gunlock, Washington Co., Torrey and Fruita, Wayne Co. This species is rather widespread, occurring in Arizona, California, New Mexico, Colorado, west Texas and northern Mexico.

HABITAT: Sandy plains, desert foothills and mesas, often associated with O. polyacantha.

OPUNTIA RUBRIFOLIA Engelm., ex Coulter, Contrib. Nat'l Herb. 3: 424,

1896. Between Comb Wash and Mexican Hat, San Juan Co. (1876). The type specimen was collected at St. George. The specimen collected at Mexican Hat is somewhat smaller than the type but apparently belongs here. New stems produced in the greenhouse have the characteristic red color.

HABITAT: Dark red sandstone and granite fragments. L. A. Woodbury (unpub.) reports a collection of this species in Zion National Park, Utah, April 23, 1930.

Opuntia Chlorotica Engelm. & Bigelow, Proc. Amer. Acad. 3: 291. 1856. Zion National Park, Washington Co., between Kanab and Johnson (1881), Kane Co. The distribution is Sonora and New Mexico to Nevada, Utah, Arizona, California and Lower California.

Habitat: On rocky hillsides and mountains usually below 4200 feet.

Opuntia fragilis (Nutt.) Haworth, Suppl. Pl. Succ. 82. 1819. Between Boulder and Torrey, Washington Co., Fruita, Wayne Co., Escalante, Washington Co., LaSal, Grand Co. (1873). This species has a wide geographic range and varies greatly in form under different conditions. It occurs in the Middle West from Wisconsin to central Kansas, and from northwest Texas to Arizona, Utah, Colorado, Oregon, Washington and British Columbia.

HABITAT: Often associated with O. polyacantha on rocky hillsides, frequently in shaded situations; in oak and yellow pine belts.

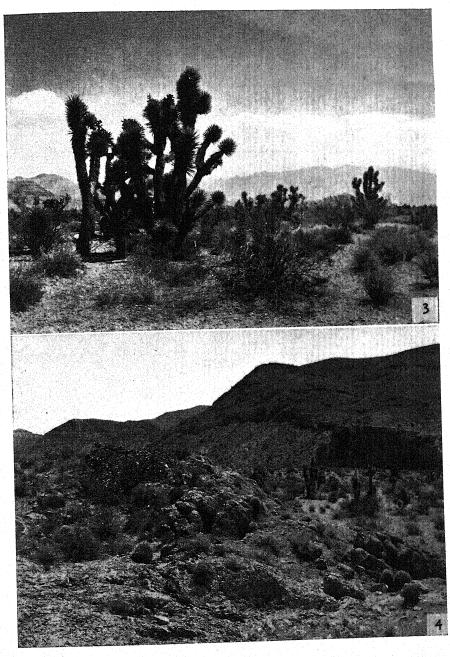
Opuntia Polyacantha Haworth, Suppl. Pl. Succ. 82. 1819. LaSal, San Juan Co., Moab, Grand Co.; Blanding and Montecello, San Juan Co., Kanab, Kane Co.; Zion National Park, Washington Co.; St. George, Washington Co. (1872); Fruita, Wayne Co.; in grassland between Hanksville and Green River. A common species in several western states from Nebraska and North Dakota to northwestern Oklahoma and Texas, from Arizona north to Alberta. Arizona and Utah are apparently the western limit.

HABITAT: Sandy soil on desert plains, where it flourishes to the point of becoming a menace to ranchers; rocky hillsides often in juniper forests or associated with yucca. The flowers of this species not only vary from yellow to orange but are often magenta. This has caused some confusion, especially since Britton and Rose give the color of the flower as lemon yellow. The author has seen these plants in bloom on the Colorado plains with both yellow and magenta flowers on the same plant. An instance is known where scientific work was being carried on presumably with two species. The plant with magenta flowers was called O. rhodantha and the yellow flowered one, O. polyacantha.

Explanation of Plate 16

Fig. 3. Joshua Forest, southwest of St. George, Washington Co., Utah. A subtropical cactus flora extends over this area.

Fig. 4. Ferocactus acanthodes and Echinocerus Engelmannii are in the foreground; Opuntia echinocarpa and Joshua trees are in the background.



CLOVER: CACTACEAE

Opuntia Rhodantha Schumann, La Semaine Hort. 1897. Zion National Park, Washington Co.; Boulder, Garfield Co. (1889); Torrey and Fruita, Wayne Co. This species is found in western Nebraska, Colorado and Utah. Helen Dixon (Bot. Gaz. 97: 272–320) reported O. xanthostemma for the southern desert region in the vicinity of Torrey. It is probable that her specimen was O. rhodantha instead, since O. xanthostemma is a doubtful species.

HABITAT: Plains, canyons and mountain sides, associated with sage-brush and piñon; also with aspen and yellow pine.

Opuntia erinacea Engelm., Proc. Amer. Acad. 3: 301. 1856. Montecello, San Juan Co.; Zion National Park, Washington Co.; St. George, Washington Co. (1895); Beaver Dam Mts.; Santa Clara Valley. Reported elsewhere from northwestern Arizona, southern Nevada, eastern California. The author has collected this species west of the Continental Divide in Colorado. It has been found frequently by Miss Carol Davidson who has collected in Colorado. Habitat: Apparently confined chiefly to the Lower Sonoran Zone. On sandy plains and on limestone hills and ledges; associated sometimes with O. polyacantha and with Echinocerei. It grows at a rather high altitude usually above 3500 feet.

Opuntia tenuispina Engelm. Proc. Amer. Acad. 3: 294. 1856. Specimens apparently correctly identified as O. tenuispina have been obtained from Zion National Park. This species was collected first in Zion National Park by L. A. Woodbury in 1930.

Opuntia Stenochila Engelm., Proc. Amer. Acad. 3: 296. 1856. Hanksville, Wayne Co. (1896). Hitherto reported from western New Mexico and northeastern Arizona. It resembles the common species of the eastern Mississippi Valley but is a lighter green, and has a slightly longer areole than the many specimens observed in the Middle West.

HABITAT: Near the banks of the Dirty Devil River, sandy soil.

ECHINOCEREUS MOJAVENSIS (Engelm. and Bigelow) Britt. & Rose, Cact. 3:8. 1922. Zion National Park, Washington Co.; Between Zion and St. George (1897); Joshua forest south of St. George; Upper Santa Clara Valley. This species is fairly abundant in western Arizona, southeastern California, Nevada and southwestern Utah. It has also been reported from Sonora.

HABITAT: Limestone outcrops and sandy calcareous soil on hillsides, usually on south and west slopes. Associated in the vicinity of St. George with E. Engelmannii, Opuntia basilaris, O. Bigelovii, Ferocactus acanthodes, Echinomastus Johnsonii and Phellosperma tetrancistra, also with Clistoyucca (Joshua tree). Found in Covillea and Artemesia areas.

Explanation of Plate 17

Fig. 5. Ferocactus acanthodes, a young plant showing the characteristic twisting of spines and the absence of hooks.

Fig. 6. Coryphantha Marstonii found on "Hell's Backbone," Boulder, Garfield Co., Utah. Type.



CLOVER: CACTACEAE

ECHINOCEREUS TRIGLOCHIDIATUS Engelm., in Wislizenus, Mem. Tour North. Mex. 93. 1848. LaSal, Grand Co. (1900). This cactus is found in western Texas, New Mexico, eastern Colorado and Utah. The author has seen specimens from the Uinta Mts., collected by E. H. Graham of the Carnegie Museum, Pittsburgh; L. A. Bradbury collected it on the Shewits Indian Reservation near St. George.

Habitat: Limestone ledges in full light and sometimes under juniper trees partially shaded. Found also on flats in sandy calcareous loam.

Echinocereus octacanthus (Muhlenpfordt) Britt. & Rose, Cact. 2: 13, 1922. LaSal National Forest, Grand Co. (1898), Comb Wash, near Mexican Hat, San Juan Co.; Fruita, Wayne Co.; Common west of the Continental Divide, Colorado; the Uinta Mts., Utah; northern Texas and New Mexico. Habitat: Limestone outcrops on ledges or hillsides. Abundant in Shavina Canyon, Montrose, Colorado. This species is unquestionably confused with E. coccineus which it closely resembles in form and habit. As far as the writer has observed from field studies in the western states E. octacanthus is much more abundant than E. coccineus, although, judging from the reports on distribution, the latter would seem to be.

ECHINOCEREUS COCCINEUS Engelm. in Wislizenus, Mem. Tour North. Mex. 94: 1848. Zion National Park; between Zion and St. George, Washington Co. (1884). This species has been found in the Uinta Mts. in western Colorado; and is reported from New Mexico and Arizona.

HABITAT: Calcareous soil, usually on ledges or hillsides; near Zion associated with E. Engelmannii and occasionally with E. mojavensis.

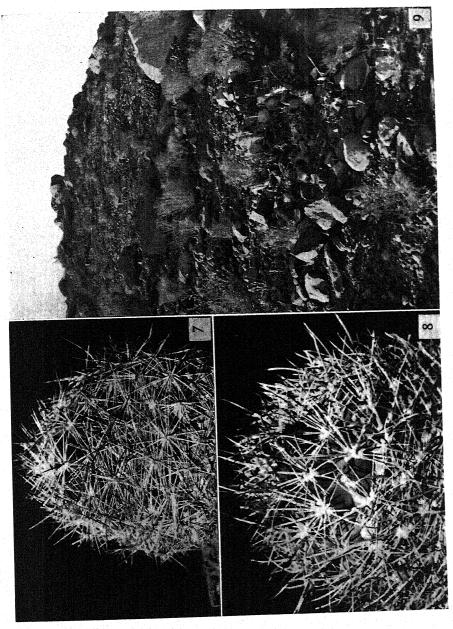
ECHINOCEREUS ENGELMANNII (Parry) Rumpler in Förster, Handb. Cact. ed. 2: 805. 1885. Mexican Hat, San Juan Co. (1878); Zion National Park; between Zion and St. George, (1880); Joshua forest south of St. George; Beaver Dam Wash; and Gunlock and Veyo, Washington Co. Distributed elsewhere in California, Arizona, Nevada, Lower California, and Sonora.

Habitat: Limestone ledges, rocky calcareous hillsides. This species seems to be able to thrive under less favorable conditions than other Utah Echinocerei, i.e., in more extreme desert conditions, and in poorer soil. Abundant in Joshua forest, often associated with *Covillea tridentata*. A specimen from Mexican Hat is said by Mrs. W. E. Nevills to have white flowers.

ECHINOCEREUS FENDLER (Engelm.) Rumpler in Förster, Handb. Cact. ed. 2: 801. 1885. Utah-Arizona border, Monument National Park (1879). This species has been collected in Texas, New Mexico, Nevada, Utah, Arizona,

Explanation of Plate 18

- Fig. 7. Coryphantha sp. nov. found between Veyo and Gunlock, Washington Co., Utah.
 - Fig. 8. Utahia Sileri. Near the Arizona-Utah; border, Fredonia, Arizona.
 - Fig. 9. Echinocereus octacanthus on a limestone hillside near Zion, Utah.



CLOVER: CACTACEAE

HABITAT: The plant is apparently extremely rare in Utah and difficult to find because its white spines blend so well with the light colored soil and limestone fragments among which it grows in the Joshua forest.

CORYPHANTHA DESERTI (Engelm.) Britt. & Rose, Cact. 3: 46. 1923. St. George, Washington Co. (1906). The range of this species has been extended the last few years; it is now known from southern California, southern Nevada, southern Utah and southwestern Colorado.

HABITAT: Desert areas in sandstone, among rocks, and on hillsides.

CORYPHANTHA AGGREGATA (Engelm.) Britt. & Rose, Cact. 4: 47–48. 1923. Blanding, San Juan Co. (1875). Distributed in western New Mexico, southeastern Arizona and along the Colorado River, southwestern Colorado, southern Utah and Sonora.

HABITAT: Found at Blanding in piñon and cedar area, limestone hills.

CORYPHANTHA CHLORANTHA (Engelm.) Britt. & Rose, Cact. 4: 43. 1923. East of St. George, Washington Co. (1907); known also from western Arizona, central Nevada and reported from southern California.

HABITAT: Hillsides, in red sandstone and often among rocks.

CORYPHANTHA ECHINUS (Engelm.) Britt. & Rose, Cact. 4: 42. 1923. LaSal National Forest, San Juan Co. (1874). The range of this plant is recorded far south of Utah, and it is surprising to find it so far north of its known habitat. The species has apparently been reported only from western Texas. Since the part of New Mexico, Utah and Arizona lying between these two regions are difficult to botanize thoroughly, it is possible that the plant has a wider distribution than we think. Two caespitose specimens were found.

HABITAT: Limestone hills, at LaSal, associated with Opuntia fragilis, O. Phaeacantha, O. polyacantha, on a hill sparsely covered with pines.

CORYPHANTHA ARIZONICA (Engelm.) Britt. & Rose, Cact. 4: 45–46. 1923. This species was not collected but was seen growing in gardens in the vicinity of St. George and was reported to have been collected locally. It has been found in northern Arizona, at Pipe Springs and near Cima and Goffs, California. Specimens closely resembling it were found by Miss Carol Davidson and the author in southwestern Colorado.

Habitat: On hills, growing at a rather high elevation.

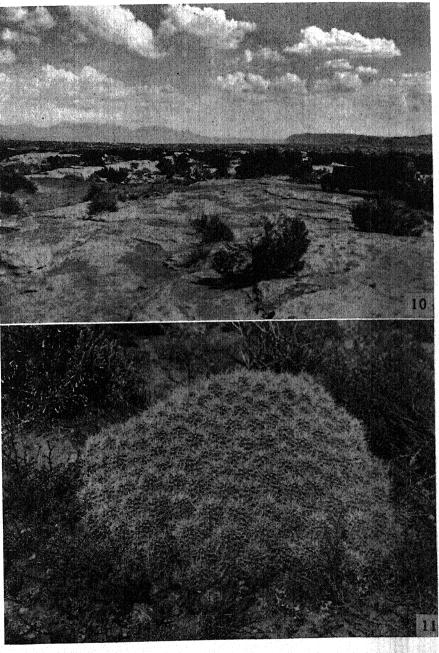
Coryphantha sp. nov.

Between Veyo and Gunlock, Washington Co. (1908). One healthy, and two dying specimens were found on a hillside in red sandstone strewn with granite fragments, associated with *Artemesia* and stunted *Covillea tridentata*. The

Explanation of Plate 19

Fig. 10. Limestone outcrop in sandstone north of Moab, Grand Co., Utah. Juniperus utahensis and Artemesia are dominant. Unhealthy plants and skeletons of Sclerocactus Whipplei and Opuntia polyacantha are found here.

Fig. 11. Echinocereus octacanthus at the base of cliffs between Montecello and Moab.



CLOVER: CACTACEAE

plant in some ways fits the description of *C. deserti*. The spines, however, are coarse and have a decidedly purplish cast, becoming black at the tip; radial spines never more than fifteen, centrals four; while *C. deserti*, according to the original description has a total of from twenty-five to thirty. Only dried flowers were available, and they appear to be yellow. The fruit is rather large, greenish purple and has a taste not unlike that of a ripe paw-paw (*Asimina*). Because of the meagre amount of material the author does not feel justified in naming this plant even as a new form until it is seen in flower.

Coryphantha Marstoni sp. nov. Caespitosa, caulibus 4.5–6.5 cm. crassis; depresso-globosa; tuberculis sub-prismaticis, summis floriferis tomentosis sulcatis; junioribus dense lanatis; areolis 1.5 mm. latis, rotundis; spinis lateralibus radiatis, superioribus 4–5, setaceis rectis, albidis, inferioribus 9–12 radiantibus, rigidis, paullo recurvis, vel translucentibus pallide luteisque vel fuscis; 10–12 mm. longioribus, centralibus 2 vel 3, fuscis, apice nigris, inferiore (ex areolae centro) subulato, porrecto, 8–10 mm. longo; superioribus 12–15 mm. longis, rectis, obliquiter radiantibus; omnibus spinis basi bulbosis; floribus parvis, in plantae apice, 2 cm. longis, luteis, stigmatis lobis 5; filamentis numerosis; antheris luteis, fructibus ignotis. Utah. Specimen typicum (1909) vivum ex loco "Boulder" dicto conservatum est in Horto Botanico Universitatis Michiganensis.

Plant caespitose, forming a low flat clump with a stout tap root 2.5-3 feet long; stems crowded so that they are misshapen, depressed-globose, 4.5-6.5 cm. in diameter; tubercles sub-prismatic, about 1 cm. long, 4-5 mm. in diameter at base, very slightly less at tip; groove not extending to the base in all the older tubercles, lower end filled with whitish wool; aeroles circular, younger ones white-wooly; radial spines of two kinds, a tuft in upper end of areole, white, sometimes brown tipped, almost hair-like, somewhat shorter than other radials, these 9-12, rigid, acicular, uneven, the longest 10-12 mm. long, slender, horn-colored to light brown with darker tips, becoming grayish with age, radiating, occasionally slightly recurved, centrals usually 3, one in the center of the areole, subulate, porrect, with a swollen base, usually less than 1 cm. long, stouter than the other spines, red-brown to almost black at the tips; 1 or 2 upper centrals swollen at the base, similar in color to first central, rigid, acicular, ascending, pointing slightly outward, 12 to 15 mm. long; spines interlocking, forming rather a dense covering; flowers formed at base of tubercles at the apex, about 2 cm. long, yellow; style extending far beyond the stamens, stigma lobes 5; flower described from a dried specimen.

Distribution: Known only from the type locality, "Hell's Backbone," a mountain ridge near Boulder, Garfield, Co., Utah (1909). Papers from the Department of Botany and the Botanical Gardens, University of Michigan, no. 645.

University of Michigan,
Ann Arbor,
Botanical Gardens and Arboritum

Response of sorghum to high and low soil moisture*

V. PANDURANGA RAO (WITH TWO FIGURES)

The grain sorghums are prominent among cereals of semiarid regions throughout the world. So far studies on sorghums have been largely confined to their morphology, genetics, and taxonomy. Only a small fraction of the voluminous literature on crop production is devoted to the highly important subject of roots and absorptive processes. That roots are the "least known, least understood, and least appreciated part of the plant" is particularly true of sorghums.

In India, sorghum is grown in a semiarid region characterized by low and irregularly distributed rainfall. Normally most of the rains fall as heavy downpours of as much as three to four inches in one day. During the last 30 years at Bellary, South India, dry cycles have occurred at intervals of four to five years with departures of six to eight inches below the 20-inch norm. Sorghum is the only grain crop that can be grown successfully under these conditions. It is also grown as a garden crop under irrigation. Hence, there is an urgent need for studying the response of this crop to widely different soil moisture content. There is little information on the subject of the response of roots of grain crops to wet and dry soils (Weaver and Clements, 1938).

MATERIAL AND METHODS

Sorghum cernuum Host, was the species used in this experiment. Screened, fertile loess soil having a wilting coefficient of about 13 per cent was secured. It was divided into two lots which were adjusted to uniform moisture contents of 33 per cent (wet soil) and 14.8 per cent (dry soil), respectively.

Eight cylindrical galvanized iron containers 75 cm. deep and 28 cm. in diameter were used. A circular hole 6.5 cm. in diameter was cut in the middle of the side of each cylinder. These holes were corked while each of the two lots of soil was tamped uniformly into four containers. Lids were sealed on the completely filled containers with water-proof adhesive tape. Then the cans, each containing about 110 pounds of soil, were horizontally embedded in soil so that only the corks remained uncovered.

After removing the corks, three seeds were planted in each hole, and a thin layer of sand was added to reduce evaporation from the opening. The soil on the greenhouse bench between the containers was also planted to sorghum in order to provide conditions of competition for light similar

^{*} Contribution from the Department of Botany, University of Nebraska, No. 106.

to those encountered in the field. Light watering until the seedlings were four days old permitted germination and establishment in the dry soil. At this time, the plants were thinned to one per container.

During the experiment, the average temperature of the soil in which the plants were rooted was 56° F. and the air temperature varied between 65° and 75° F. The short light period of the winter days was extended until 10:00 p.m. by the use of two 150-watt electric lights mounted in 15-inch, white, enameled reflectors placed 3 feet above the containers. These were also used on cloudy days. The intensity of the light thus provided at 7:00 p.m. was 38 foot candles as compared with 3,000 foot candles at midday. Average daily evaporation from Livingston's black spherical atmometers was 11.6 cc., and relative humidity ranged from 55 to 60 per cent.

At the end of 42 days, the walls of the containers were cut open and the root systems washed free of soil. The volume of the roots was obtained by displacement of water in a graduated cylinder after they had been pressed between paper towels to remove surface water. The root systems were then floated out in deep pans of water in approximately the position occupied in the phytometer. Calculation of the total area of the root system selected as average was based on the total number and length of roots and the average diameters, as measured with the compound microscope and micrometer scale. Root hairs were thus excluded. This method was developed by Weaver et al (1924). The typical root system selected was also drawn to scale on cross-ruled paper while it was floating in its natural position over black paper ruled in square centimeters. The areas of above-ground parts were measured by first making prints on solio paper of the flattened leaves and stems and then using a planimeter. Finally, roots and tops were weighed after drying them at 90° F. for 24 hours.

RESULTS

Plants Grown in Moist Soil

The plants grown in moist soil, as measured to the tip of the youngest leaf, were 25.9 cm. tall and had stems 15 cm. long. The eight leaves had a surface area—upper and lower combined—of 299.7 sq. cm. (table 1). The ratio of shoot area to root area (excluding root hairs) was 1.95:1. The dry weight ratio, similarly, was 2:1. There were present 10 primary roots (fig. 1) which ranged from 8.6 to 42.0 cm. long and had a combined length of 265.2 cm. They were white and very turgid. Their diameters were between .25 and 1.0 mm. and averaged .725 mm.

The area of the primary roots (47.35 sq. cm.) constituted 30.9 per cent of the area of the entire root system. Arising from the primaries were

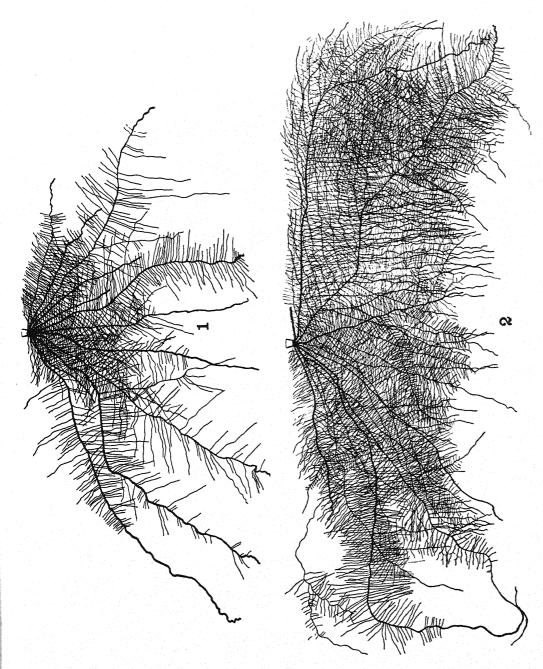


Fig. 1. Root habits of sorghum plants. Plants grown in (1) moist soil, and (2) dry soil, $\times 1$.

758 short, white secondaries with a total length of 1,178.6 cm. and an area of 90.7 sq. cm. or 59.3 per cent of the total area. Roots of the third and fourth order provided 9.1 and .7 per cent, respectively, of the total area (153 sq. cm.) of the root system.

TABLE 1

Response of 42-day-old sorghum plants to high and low water content

eight of plant, cm. 'umber of leaves hotosynthetic area of tops, sq. cm. bry weight of tops, gram	25.9 8 299.67	21.0
umber of leaves hotosynthetic area of tops, sq. cm.	8 299.67	
hotosynthetic area of tops, sq. cm.	299.67	000 04
hotosynthetic area of tops, sq. cm.		222.34
weight of tone gram	0.317	0.252
ry weight of tops, Starr	0.153	0.246
ry weight of roots, gram	1.25	1.84
olume of roots, cc.	1.20	
	10	8
Tumber of primary roots	758	1,007
Tumber of secondary roots	470	1,952
Tumber of tertiary roots	101	354
Number of quaternary roots	1,339	3,321
Cotal number of roots	1,000	
	265.2	328.0
ength of primary roots, cm.	1,178.6	3,017.9
length of secondary roots, cm.	415.8	2,649.5
length of tertiary roots, cm.	51.0	177.0
Length of quaternary roots, cm.	1,910.6	6,172.4
Total length of root system, cm.	1,910.0	
	47.35	57.40
Absorbing area of primary roots, sq. cm.	90.70	265.60
Absorbing area of secondary roots, sq. cm.	13.85	116.60
Absorbing area of tertiary roots, sq. cm.	1.13	3.90
Absorbing area of quaternary roots, sq. cm.	153.03	443.50
Total absorbing area of roots, sq. cm.	133.00	
	33.0	83.4
Number of root hairs per unit length Average length of root hairs, µ	229	136

The root hairs constituted by far the best absorptive agency of the plant. It was practically impossible to measure their total area because of their minuteness and abundance. However, microscopic determinations of their length and general distribution were made at different levels of the root system. The average number of root hairs per unit length (700μ) at fifty different levels was 33, with a maximum (in any unit length) of 41 and a minimum of 26. Only those root hairs visible on either side of the root when viewed through the microscope were counted. The average length of root hairs, determined from 500 readings at different levels in

all roots, was 229μ , the distribution in length varying from 525μ to 105μ . The average volume of the root systems of four plants was 1.25 cc., the average dry weight .153 grams.

Plants Grown in Dry Soil

The plants grown in soil with approximately 1.8 per cent available moisture had eight leaves when 42 days old. They were 21 cm. tall and had stems 12.5 cm. long. The surface area of the shoot was 222.34 sq. cm., that of the root system 99 per cent greater. The average dry weight of tops was .252 gm. (table 1). The ratio of dry weight of tops to that of roots was 1.02:1.

The eight primary roots ranged in length from 2.5 to 130.7 cm. and had a combined length of 328 cm. The longest one consisted of a main root and six branches from its tip. These eight roots varied in diameter from .25 to 1.0 mm., the average being .5 mm. They were light brownish yellow in color. The area of the primary roots (57.4 sq. cm.) was 12.9 per cent of that of the root system.

There were 1,007 secondary roots with a total length of 3,017.9 cm. They were discolored like the primaries. Their area of 265.6 sq. cm. was 59.9 per cent of that of the root system. The 1,952 tertiary roots had a combined length of 2,649.5 cm. and an area of 116.6 sq. cm. This was 26.3 per cent of the total area and with the area of the secondaries composed 86.2 per cent of the total. The 3.9 sq. cm. area of the quaternary roots was distributed among 354 roots with a total length of 177 cm. This was .9 per cent of the whole 443.5 sq. cm. area of the root system.

The average number of root hairs per unit length of 700μ taken at fifty different levels was 83.4, and ranged from 68 to 118; their average length, as obtained from 500 measurements at different levels in all roots, was 136μ , the length varying from 70 to 287μ .

Average dry weight and volume of the root systems were .246 gm. and 1.84 cc., respectively.

DISCUSSION

Comparison of the foregoing data shows that low soil moisture content inhibited the growth of the shoot of sorghum while increasing the number and length of all orders of roots (except number of primaries). The primary roots were 1.24 times longer, secondaries 2.57 times, the tertiaries 6.37 times, and roots of the fourth order 3.47 times longer than those of moist soil. There were 1.33 times more secondaries, 4.15 times more tertiaries, and roots of the fourth order were 3.5 times more numerous. Stated conversely, moist soil favored the growth of tops and primary roots but

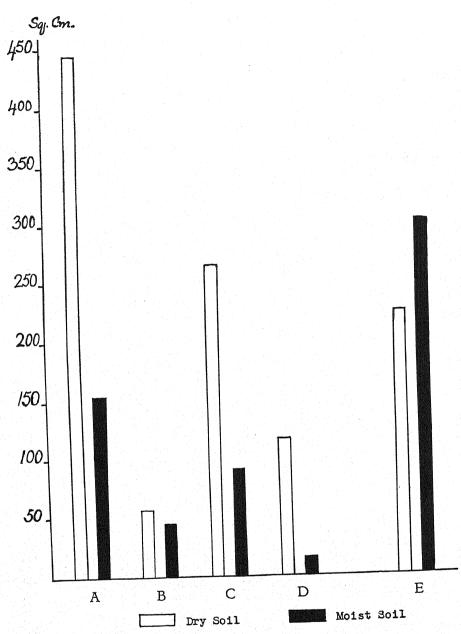


Fig. 2. Graph showing the relationship between: A, the area of the entire root system; B, the area of the primary roots; C, the area of the secondary roots; D, the area of the tertiary roots; and E, the photosynthetic and transpiring areas of *Sorghum* plants grown in dry and moist soil.

checked that of secondary, tertiary, and quaternary roots. The total length of the roots in dry soil (6,172.4 cm.) was 3.23 times as great as in plants grown in moist soil, and the root area in the former was 2.9 times that in the latter. In dry soil, root hairs were more numerous (83.4 per unit of length) and shorter (136 μ) than in moist soil where the number was 33 and the length 229 μ .

It is noteworthy that the dry soil dwarfed the shoot while accentuating root development (fig. 2). This tends toward an equilibrium between absorption of water and its loss in transpiration. In a similar study but using a more mesic species, Weaver and Clements (1938) found that "Corn grown for 5 weeks in a moist, rich, loess soil (available water content 19 per cent) had a total root area which was 1.2 times greater than that of the transpiring surface of stems and leaves. Similar corn grown with an available water content of only 9 per cent had a root area 2.1 times greater than that of tops Thus, a low water content, within certain limits, stimulates increased root development" of maize. Most of the increased absorbing area was furnished by "an excellent development of secondary and tertiary branches."

In this experiment, the root area of sorghum in moist soil was much less than the photosynthetic area, but in dry soil it was double the photosynthetic area. The primary roots in the dry soil were thinner and longer and constituted only 13 per cent of the total root area, whereas those in the moist soil were thicker and shorter and composed 31 per cent of the area of the root system. In moist soil the primaries and secondaries dominated, but in dry soil the secondary and tertiary roots provided the largest area. The capacity of the plant to elaborate its root system and at the same time to meet the stress of drought by limiting the development of its shoot is especially noteworthy (fig. 2).

SUMMARY

Sorghum plants were grown for 42 days in soils with 33.0 and 14.8 per cent moisture of which only about 20 and 1.8 per cent, respectively, were available for growth, *i.e.*, above the hygroscopic coefficient.

Plants grown in moist soil were one-fourth taller and heavier and had one-third more photosynthetic area than those grown in dry soil. In moist soil the dried tops were twice as heavy as the roots but in dry soil the weight of tops and roots was the same. Haasis (1921), and Crist and Stout (1929) also found that the dry weight ratio of shoot to root is proportional to available soil moisture. The plants grown in dry soil had more and longer roots and nearly three times the area of those in moist soil.

Under both treatments, well developed secondary roots were produced. The moist soil proved more favorable to the development of primary roots, but the tertiaries were better in dry soil. Volumes of root systems in the moist and dry soils averaged 1.25 cc. and 1.84 cc., respectively. In the latter, root hairs were more abundant but shorter. Dryness of soil stimulated root growth considerably and inhibited the growth of aboveground parts.

The author wishes to express his sincere gratitude to Dr. J. E. Weaver for suggesting the problem and for interest shown throughout the work.

Literature cited

- Crist, J. W., and G. J. Stout. 1929. Relation between top and root size in herbaceous plants. Plant Physiology 4: 63-85.
- Haasis, F. W. 1921. Relations between soil type and root form of western yellow pine seedlings. Ecology 2: 292-303.
- Weaver, J. E., J. Kramer, and M. Reed. 1924. Development of root and shoot of winter wheat under field environment. Ecology 5: 26-50.
- ., and F. E. Clements. 1938. Plant ecology. 2nd ed. p. 296 New York: McGraw-Hill Book Co.

INDEX TO AMERICAN BOTANICAL LITERATURE 1935-1937

The aim of this Index is to include all current botanical literature written by American, published in America, or based upon American material; the

word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

- Atwood, S. The nature of the last premeiotic mitosis and its relation to meiosis in *Gaillardia*. La Cellule 46: 391-409. f. 1-54. 1937.
- Azeredo-Penna, L. de. O vento e a vegetacao. Rodriguesia 2º: 97-99. f. 1, 2. 1937.
- Azeredo-Penna, L. de. Floracao de Inverno. Rodriguesia 29: 107-111. 1937.
- Azevedo, N. Replacao bibliographica referente a fungos e doencas do cafeeiro. Rodriguesia 2: (Spec. No.) 213-238. 1936.
- Beilmann, A. P. The behavior of a basswood during an artificial windstorm. Missouri Bot. Gard. Bull. 26: 50-56. F 1938.
- Beilmann, A. P. The Chinese elm. Missouri Bot. Gard. Bull. 26: 48-50. F 1938.
- Benatar, R. Contribuicao ao estudo bibliographico de doencas da roseira. Rodriguesia 2: (Spec. No.) 239-264. 1936.
- Berry, E. W. A representative of the Olacaceae in the Eocene of southeastern North America. Torreya 38:5-7. Ja-F 1938.
- Berry, E. W. Additional Miocene plants from Grand Coulee, Washington. Bull. Torrey Club 65: 89-98. f. 1-8. F 1938.
- Bitancourt, A. A. & Jenkins, A. E. Variacoes de *Elsinoe australis* Bitancourt e Jenkins. Rodriguesia 2: (Spec. No.) 315-317. f. 1. 1936.
- Blake, S. F. Two new Asteraceae from the Charleston Mountains, Nevada. Proc. Biol. Soc. Washington 51: 7-10. 18 F 1938.
- Blakeslee, A. F. & Avery, A. G. Methods of inducing doubling of chromosomes in plants. Jour. Heredity 28: 393-411. f. 1-11. D 1937.
- Borgmeier, T. A historia da "Flora Fluminensis." de Frei Vellosa. Rodriguesia 2º: 77-96. 1937.
- Boyle, L. W. & McKinney, H. H. Local virus infections in relation to leaf epidermal cells. Phytopathology 28: 114-122. F 1938.

- Braun-Blanquet, J. Plant Sociology. i-xviii, 1-439. f. 1-180. New York. McGraw-Hill Book Co. 1932. Translated and edited by Fuller, G. D. and Conard, H. S.
- Brierley, P. & McKay, M. B. Experiments with aphids as vectors of tulip breaking. Phytopathology 28: 123-129. F 1938.
- Brown, H. P. & Panshin, A. J. Identification of the commercial timbers of the United States, i-xxvi. 1-223. f. 1-274. pl. 1-60. New York, McGraw-Hill Book Co. 1934.
- Brunel, J. Qu'est-ce que le Spirulina vaginata de Kaiser? Nat. Canadien 64: 290-292. f. 1-4. N 1937.
- Clark, W. G. Polar transport of auxin and electrical polarity in coleoptile of *Avena*. Plant Physiol. 12: 737-754. f. 1. Il 1937.
- Clayton, E. E. & Gaines, J. G. Blue mold (downy mildew) disease of tobacco. U. S. Dept. Agr. Farm. Bull. 1799: 1-16. f. 1-9. Ja 1938.
- Cleonique-Joseph, Frere. Sur quelques additions a la flore du Quebec. Nat. Canadien 64: 254-258. O 1937.
- Clute, W. N. Meaning of plant names. LXXIII. Rues and milkworts. Am. Bot. 44: 10-17. Ja 1938.
- Clute, W. N. The Christmas rose. Am. Bot. 44: 1-4. illust. Ja 1938.
- Coffman, F. A. & Stevens, H. Influence of certain oat varieties on their F₁ progeny. Jour. Am. Soc. Agron. 29: 314-323. f. 1-3. Ap 1937.
- Cook, M. T. Pioneers in the study of virus diseases of plants. Sci. Monthly 46: 41-46. illust. Ja 1938.
- Darrah, W. C. Fossil plants and evolution. Evolution 4: 5, 6. Ja 1938.
 - Dayton, W. A. & others. Range plant handbook. illust. Forest Serv. U. S. Dept. Agr., Washington. 1937.
 - Dobzhansky, T. Genetics and the origin of species. i-xvi. 1-364. Columbia Univ. Press. 1937.
 - Drechsler, C. Two hyphomycetes parasitic on oospores of rootrotting oomycetes. Phytopathology 28: 81-103. f. 1-4. F 1938.
 - Dunn, S. Value of the dye-adsorption test for predetermining the degree of hardiness. Plant Physiol. 12:869-874. Jl 1937.
 - Eastwood, A. Two new wallflowers. Leafl. West. Bot. 2:73,74. Ja 1938.
 - Emmert, E. M. Application of the chlorate method for determining nitrogen to light, fluffy materials. Plant Physiol. 12: 999-1001. O 1937.

Epling, C. Synopsis of the South American Labiatae. Part 3. Repert. Spec. Nov. Beih. 85: 193–228. 15 S 1936.

Epling, C. The Labiatae of Bolivia. Revista Sudam. Bot. 4: 21-53. Ja 1937.

Everett, T. H. Plant exploration in the Rockies. Hort. Soc. N. Y. Bull. 1937: 6-8. D 1937.

Everett, T. H. Eine Titanenwurz blüht auf. Gartenschönheit 19: 47-50. illust. F 1938.

Eyerdam, W. J. New records of noteworthy northwestern plants. Leafl. West. Bot. 2: 78. Ja 1938.

Florell, V. H. Native grasslands in the Huron (South Dakota) area. Jour. Am. Soc. Agron. 29: 403-411. f. 1-6. My 1937.

Fogg, J. M. Lophotocarpus spongiosus in Salem County, New Jersey. Bartonia 17: 21, 22. 2 Ap 1936.

Forbes, R. D. "Mikes," a botanical engima. Sci. Monthly 46: 32-40. illust. Ja 1938.

Foster, A. C. & Tatman, E. C. Environmental conditions influencing the development of tomato pockets or puffs. Plant Physiol. 12: 875-880. Jl 1937.

Fries, R. E. Revision der Arten einiger Annonaceen-Gatungen. Acta Hort. Bergiani 12: 221-228. pl. 1-8. f. 1-11. 1937.

Frye, T. C. Ferns of the northwest. 1-177. f. 1-62. Portland, Oregon. Metropolitan Press. 1934.

Fulling, E. H. Reliable evergreens for the northeastern states. Jour. N. Y. Bot. Gard. 39: 36, 37. illust. F 1938.

Fulling, E. H. Some choice coniferous evergreens for ornamental planting. Jour. N. Y. Bot. Gard. 39: 25-31. illust. F 1938.

Gates, F. C. Grasses in Kansas. Rep. Kansas Board Agr. 55: 1-349. f. 1-270. 1937.

Giesen, H. Triuridaceae. In Engler, A. Pflanzenreich 104(IV.18): 1-84. f. 1-18. 1938.

Glock, W. S. Principles and methods of tree-ring analysis. Carnegie Inst. Publ. 486: 1-100. pl. 1-14. 15 S 1937.

Graham, E. H. Botanical studies in the Uinta Basin of Utah and Colorado. Ann. Carnegie Mus. 26: 1-432. pl. 1-13. 1937.

Granick, S. Urease distribution in Canavalia ensiformis. Plant Physiol. 12: 601-623. f. 1-10. Jl 1937.

Greathouse, G. A. & Stuart, N. W. Enzyme activity in cold-hardened and unhardened red clover. Plant Physiol. 12: 685-702. Jl 1937.

Greenleaf, W. H. Induction of polyploidy in *Nicotiana*. Science II 86: 565-566. 17 D 1937.

Howell, J. T. A collection of Douglas' western American plants—II. Leafl. West. Bot. 2: 74-77. Ja 1938.

Howell, J. T. A new Mimulus. Leafl. West. Bot. 2: 79, 80.
Ja 1938.

Howell, J. T. New varieties of western plants—II. Leafl. West. Bot. 2: 70, 71. Ja 1938.

Hrdlicka, A. Man and plants in Alaska. Science II 86: 559-560. 17 D 1937.

Hume, H. H. The genus Cooperia. Bull. Torrey Club 65: 79-87.

1 F 1938.

Johnston, I. M. Notes on some Astragalus species of Ecuador and Peru. Jour. Arnold Arbor. 19: 88-96. Ja 1938.

Jump, J. A. A new fungus on *Ficus nitida* Thumb. Jour. Agr. Univ. Puerto Rico. 21: 573, 574. O 1937.

Jump, J. A. A new disturbance of red pine. Science 87: 138-139. 11 F 1938.

Kramer, P. J. Photoperiodic stimulation of growth by artificial light as a cause of winter killing. Plant Physiol. 12: 881–883. Il. 1937.

Krausche, K. K. & Gilbert, B. E. Increase of transpiration rates of tomato leaves due to copper sprays. Plant Physiol. 12: 853-860. Jl 1937.

Krug, H. P. Fusarium como causador da murcha do algodoeiro. Rodriguesia 2: (Spec. No.) 319-320. 1936.

La Fuze, H. H. Nutritional characteristics of certain wooddestroying fungi, *Polyporous betulinus* Fr., *Fomes pinicola* (Fr.) Cooke, and *Polystictus versicolor* Fr. Plant Physiol. 12: 625-646. Jl 1937.

LeClerg, E. L. Further studies on the parasitism of *Rhizoctonia* solani on sugar beets. Phytopathology 28: 152, 153. f. 1. F 1938.

Lemmon, W. P. A new gentian from Georgia. Bartonia 17: 4. 2 Ap 1936.

Leukel, R. W. Studies on bunt, or stinking smut, of wheat and its control. U. S. Dep. Agr. Tech. Bull. 582: 1-47. N 1937.

Lillo, M. Catalogo de las Acantaceas Argentinas. Lilloa 1: 21-66. illust. 1937.

Linsbauer, L. Fifty years of plant physiology in Austria. Plant Physiol. 12: 565-569. Jl. 1937.

Loesener, T. Celastraceae novae vel minus cognoscundae. II. Notizbl. Bot. Gart. Berlin 13: 215-226. 15 Jl 1936.

Lubimenko, V. N. Plant physiology in the U. S. S. R. Plant Physiol. 12: 895-897. O 1937.

- Lutman, B. F. Microbiology. i-x. 1-495. f. 1-211. New York, McGraw-Hill Book Co. 1929.
- Marsh, G. Effect of temperature upon the inherent potential of *Valonia*. Carnegie Inst. Publ. 475: 1-16. f. 1-3. O 1937.
- Marsh, G. Proof of the flux equilibrium relation. Plant Physiol. 12: 861-867. f. 1-3. Jl 1937.
- Mathews, F. S. Familiar flowers of field and garden. i-xv. 1-310. *illust*. New York, D. Appleton-Century Co. 1937.
- McLean, F. T. "Glad." gossip—I. Flower Grow. 25: 133, 145. Mr 1938.
- McLean, F. T. Trees in profile. Jour. N. Y. Bot. Gard. 38: 274-280. illust. D 1937.
- Mello Barreto, H. L. de. Quatro Lavoisieras novas. Bol. Mus. Nac. Rio de Janeiro 12: 57-72. illust. Mr 1936.
- Merrill, E. D. New or noteworthy Indo-Chinese plants. Jour. Arnold Arbor. 19: 21-70. f. 1-3. Ja 1938.
- Merrill, E. D. Unrecorded plants from Kwangtung. IV. Lingnan Sci. Jour. 15: 415-429. f. 1. 24 Jl 1936.
- Merrill, E. D. & Perry, L. M. A synopsis of *Acmena DC.*, a valid genus of the Myrtaceae. Jour. Arnold Arbor. 19: 1-20. Ja 1938.
- Miller, E. S. A precise method with detailed calibration for the determination of absorption coefficients; the quantitative measurement of the visible and ultraviolet absorption spectra of Alpha carotene, Beta carotene, and lycopene. Plant Physiol. 12: 667-684. f. 1-8. Jl 1937.
- Moldenke, H. N. A further supplement to Edition 3 of H. N. Moldenke's The observed flora of Watchung, N. J., and its immediate vicinity. 1. N. Y. Bot. Gard. 28 Au 1937.
- Moreland, C. F. Leaf temperatures of sugar cane. Plant Physiol. 12: 989-995. O 1937.
- Muenscher, W. C. Lilaea subulata in Washington. Torreya 38: 8. Ja-F 1938.
- Muller, A. S. Tres especies de Septobasidium sobre Citrus em Minas Geraes. Rodriguesia 2: (Spec. No.) 351-354. 1936.
- Mundkür, B. B. Host range and identity of the smut causing root galls in the genus *Brassica*. Phytopathology 28: 129-142. f. 1-3. F 1938.
- Munz, P. A. Studies in Onagraceae XI. A revision of the genus Gaura. Bull. Torrey Club 65: 105-122. f. 1-18. 1 F 1938.
- Munz, P. A. Interesting western plants—I. Leafl. West. Bot. 2: 65-70. *illust*. Ja 1938.

- Otero, J. I. & Cook, M. T. A bibliography of mycology and phytopathology of Central and South America, Mexico and the West Indies. Univ. Puerto Rico Jour. Agr. 21: 249-486. Jl 1937.
- Palmer, E. J. Adventures in fern collecting. II. Am. Fern Jour. 26: 136-139. O-D 1936.
- Parker, D. Affinities of the flora of Indiana. I. Am. Midl. Nat. 17: 700-724. f. 1-113. Jl 1936.
- Parks, H. B. Valuable plants native to Texas. Texas Agr. Exp. Sta. Bull. 551: 1-173. f. 1. Au 1937.
- Parodi, L. R. Revision de las Gramíneas del genero *Tridens* de las flora Argentina. Rev. Argentina Agron. 4: 258-272. f. 1-4. D 1937.
- Parodi, L. R. Nota sobre la multiplicación vegetativa de (Pterogyne nitens). Rev. Argentina Agron. 4: 305-307. illust. D 1937.
- Parodi, L. R. La floración de *Phyllostachys aurea* en la Argentina. Rev. Argentina Agron. 4: 307, 308. D 1937.
- Parodi, L. R. Contribución al estudio de las Gramíneas del género (*Paspalum*) de las flora Uruguaya. Rev. Mus. Univ. Nac. La Plata 1: 211-250. f. 1-9.+pl. 1. 1937.
- Parodi, L. R. Una nueva especie de (*Paspalum*) de la flora Argentina. Notas. Mus. Univ. Nac. La Plata 2: 101-104. illust. S 1937.
- Perez Arbelaez, E. Plantas utiles de Colombia I. Bol. Agr. Bogota. (Suppl.) 1-172. f. 1-116. 1936.
- Pickel, D. B. Lista das molestias e dos fungos parasitarios das plantas cultivadas em Pernambuco. Rodriguesia 2: (Spec. No.) 207–212. 1936.
- Piland, J. R. & Willis L. G. The stimulation of seedling plants by organic matter. Jour. Am. Soc. Agron. 29: 324-331. f. 1-5. Ap 1937.
- Porterfield, W. N. The Chinese water-chestnut, Scirpus tuberosus. Jour. N. Y. Bot. Gard. 39: 32-38. illust. F 1938.
- Potbury, S. S. The La Porte flora of Plumas County, California. Carnegie Inst. Publ. 465: 29-81. pl. 1-19. 1937.
- Pound, F. J. History and cultivation of the Tonka bean (*Dipteryx odorata*) with analysis of Trinidad, Venezuelan and Brazilian samples. Trop. Agr. 15: 28-32. F 1938.
- Prescott, G. W. A new species and a new variety of the algal genus *Vaucheria* De Candolle with notes on the genus. Trans. Am. Micros. Soc. 42: 1-10. pl. 1, 2. Ja 1938.
- Preston, R. D. The contents of the vessels of Fraxinus americana L., with respect to the ascent of sap. Ann. Bot. II⁵: 1-21. f. 1-5. Ja 1938.

- Pritham, G. H. & Anderson, A. K. The carbon metabolism of Fusarium lycopersici on glucose. Jour. Agr. Res. 55: 937-949. f. 1-4. 15 D 1937.
- Pulle, A. Flora of Suriname. (Netherlands Guyana) 2¹: 337-400. 1937.

Hernandiaceae contributed by A. J. G. H. Kostermans, Sapindaceae by H. Uittien and Capparidaceae by J. C. Went.

Pulle, A. Flora of Suriname. (Netherlands Guyana) 31: 305-336. 1937.

Passifloraceae contributed by C. P. Killip and Ochnaceae by C. Wehlburg.

Pulle, A. Flora of Suriname. (Netherlands Guyana) 4: 433–513. 1937.

Myrsinaceae contributed by Bottelier, additions and corrections of the following Apocynaceae by F. Markgraf, Convolvulaceae by S. J. Van Ooststroom, Loganiceae and Boraginaceae by H. Uittien, Rubiaceae by C. E. B. Bremekamp, Ericaceae and Campanulaceae by J. Lanjouw and Labiatae by A. Kostermans

- Purpus, J. A. Echinocereus pensilis (K. Brandegee) J. A. Purpus. Kakteenkunde 12: 180–182. illust. D 1937.
- Puttemans, A. Relação dos fungus e bacterias encontrados na batateira (*Solanum tuberosum* L.) Rodriguesia 2: (Spec. No.) 265-302. 1936.
- Puttemans, A. Reivindicação visando a denominação scientifica da doença da batateira. Rodriguesia 2: (Spec. No.) 341–350. 1936.
- Raines, M. A. & Travis, C. W. Seasonal variation in elongation of young seedling radicles. Plant Physiol. 12: 997, 998. O 1937.
- Rehder, A. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. Jour. Arnold Arbor. 19: 71-87. pl. 217, 218. Ja 1938.
- Rost, E. C. Opuntia Bigelovii Engelmann. Desert 10: 13. illust. Ja 1938.
- Sanborn, E. I. The Comstock flora of west central Oregon. Carnegie Inst. Publ. 465: 1-28. pl. 1-10. 1937.
- Sandwith, N. Y. Valeriana parnassiifolia Sandwith. Hooker's Icon. Plant. 34: pl. 3349. S 1937.

A new species from Argentina.

- Schaffner, J. H. Stability and unstability of sexual conditions in *Morus alba*. Jour. Heredity 28: 426, 427. D 1937.
- Schroder, H. H. Kapok tree. Nature Mag. 31: 170. illust. Mr 1938.
- Schulz, W. G. A century of sugar pine. Nature Mag. 31: 167-170. illust. Mr 1938.

- Schweinfurth, C. New orchids from Central America. Harvard Univ. Bot. Mus. Leafl. 5: 89-104. F 1938.
- Schweinfurth, C. Epidendrum pansamalae Schlecter. Harvard Univ. Bot. Mus. Leafl. 5: 144. 5 Mr 1938.
- Sealy, J. R. Hippeastrum Blumenavia Amaryllidaceae. Curt. Bot. Mag. 160: pl. 9504. f. 1-4. Ja 1938.
- Sealy, J. R. Senecio Tabacon Compositae. Curt. Bot. Mag. 160: pl. 9512. f. 1, 2. Ja 1938.
- Shands, R. G. Longevity of *Gibberella saubinetii* and other fungi in barley kernels and its relation to the emetic effect. Phytopathology 27: 749-762. f. 1. Jl 1937.
- Shanor, L. Observations on the development and cytology of the sexual organs of *Thraustotheca clavata* (DeBary) Humph. Jour. Elisha Mitchell Sci. Soc. 53: 119-136. pl. 12, 13. Jl 1937.
- Skottsberg, C. Further remarks on Hawaiian Artemisiae. Bot. Mag. Japan 51: 196-202. f. 1-45. My 1937.
- Skvortzow, B. V. Diatoms from Lake Michigan—I. Am. Midl. Nat. 18: 652-658. pl. 1. Jl 1937.
- Sleeth, B. & Bidwell, C. B. Polyporus hispidus and a canker of oaks. Jour. Forestry 35: 778-785. f. 1, 2. Au 1937.
- Small, J. K. The jungles of Manhattan Island I. Jour. N. Y. Bot.Gard. 37:201-207. S1936. II. 38:208-216. f. 1-3. S1937.
- Smith, A. H. Unusual agarics from Michigan. IV. Papers Michigan Acad. Sci. 22: 215-223. pl. 20-24+f. 7. Je 1937.
- Smith, E. L. The influence of light and carbon dioxide on photosynthesis. Jour. Gen. Physiol. 20:807-830. f. 1-8. 20 Jl 1937.
- Smith, H. B. Number of stomata in *Phaseolus vulgaris* studied with the analysis of variance technique. Am. Jour. Bot. 24: 384-387. Je 1937.
- Smith, L. B. A new *Columnea* from Jamaica. Rhodora 39: 275-276. f. 1, 2. Jl 1937.
- /Smock, R. M. Morphology of the flower and fruit of the Loquat. Hilgardia 10: 615-632. pl. 1-4+f. 1-5. My 1937.
 - Spence, L. E. Root studies of important range plants of the Boise River watershed. Jour. Forestry 35: 747-754. f. 1. Au 1937.
 - Sprague, R. New or noteworthy parasitic species of Fungi Imperfecti in Oregon. Mycologia 29: 426-433. Jl-Au 1937.
 - Stahl, A. Estudios sobre la flora de Puerto Rico. Ed. II. 1: 1-343; 2: 1-165. Publ. Fed. Emerg. Relief Admin. Puerto Rico. 1936.
 - Standley, P. C. Three new plants from Texas and Mexico and some recent additions to the Texan flora. Am. Midl. Nat. 18: 683-684. Jl 1937.

- Stebbins, G. L. Two new species of Lactuca from tropical Africa. Bull. Jard. Bot. Bruxelles 14: 223-226. f. 19. N 1936.
- Steere, W. C. Mosses of the G. Allan Hancock Expedition of 1934, collected by Wm. R. Taylor. The Hancock Pacific Expeditions 3¹: 1-12. pl. 1. F 1936.
- Stewart, L. M. Studies in the life history of Nitella hyalina Agardh. Jour. Elisha Mitchell Sci. Soc. 53: 173-190. pl. 16-19+f. 1. Jl 1937.
- Svenson, H. K. Monographic studies in the genus *Eleocharis*. IV. Rhodora **39**: 210-231. Je 1937; 236-273. pl. 460-465. Jl 1937.
- Swezey, A. W. Cactus anatomy. Desert 9: 87-89, 94-95. illust. Au 1937.
- Taubenhaus, J. J. & Watkins, G. M. Phymatotrichum silvicolum n. sp.: its structure and development. Am. Jour. Bot. 24: 387-390. f. 1-22. Je 1937.
- Taylor, C. F. & Blodgett, F. M. Control of a wilt disease of potato by formaldehyde dust. Am. Potato Jour. 14: 154-157. My 1937.
- Taylor, W. R. Notes on north Atlantic marine algae. I. Papers Michigan Acad. Sci. 22: 225-233. pl. 25-27. Je 1937.
- Tehon, L. R. Notes on the parasitic fungi of Illinois—VI. Mycologia 29: 434-446. f. 1-9. Jl-Au 1937.
- Thomas, H. E. Apple mosaic. Hilgardia 10: 581-588. f. 1-3. My 1937.
- Thomas, W. S. The beefsteak mushroom. Jour. N. Y. Bot. Gard. 38: 201-207. illust. S 1937.
- Thornberry, H. H. & Anderson, H. W. Some bacterial diseases of plants in Illinois. Phytopathology 27: 946-949. S 1937.
- Tompkins, C. M. A transmissible mosaic disease of cauliflower. Jour. Agr. Res. 55: 33-46. f. 1-5. 1 Jl 1937.
- Tompkins, C. M. & Tucker, C. M. Phytophthora rot of honeydew melon. Jour. Agr. Res. 54: 933-944. f. 1-4. 15 Je 1937.
- Torres, J. P. Some notes on avocado flower. Philippine Jour. Agr. 7: 207-227. 1936.
- Torrey, R. H. Botanizing in the Shickshock mountains of Gaspé, Quebec. Torreya 37: 73-79. Jl-Au 1937.
- **Tschudy, R. H.** Experimental morphology of some species of *Chaetomium*. I. Use of cultural reactions in determining species characteristics. Am. Jour. Bot. **24**: 472–480. *f.* 1–15. Jl 1937.
- Tullis, E. C. & Cralley, E. M. Laboratory and field studies on the development and control of stem rot of rice. Univ. Arkansas Agr. Exp. Sta. Bull. 295: 1-23. f. 1-6. D 1933.

Ullstrup, A. J. Histological studies on wilt of China aster. Phytopathology 27: 737-748. f. 1-5. Jl 1937.

Uphof, J. C. T. Sarraceniaceae. Natür. Pflanzenfamilien Ed. 2. 17^b: 704-727. f. 437-452. 1936.

Ware, J. O. Genetic relations of nankeen lint to plant color and leaf shape in upland cotton. Univ. Arkansas Agr. Exp. Sta. Bull. 300: 1-44. My 1934.

Ware, J. O. Genetic relations of red plant color, leaf shape and fibre colors in upland cotton. Univ. Arkansas Agr. Exp. Sta. Bull. 294: 1-60. Je 1933.

Warmke, H. E. Cytology of the Pacific coast trilliums. Am. Jour. Bot. 24: 376-383. f. 1-24. Je 1937.

Watkins, G. M. & Muller, C. H. An occurrence of Sphaerotheca lanestris in Mexico. Am. Midl. Nat. 18: 659-660. f. 1. [1 1937.

Watkins, J. V. Experiments with hormodin on tropical and semi-tropical plants. Florists Exch. 893: 20, 36. f. 1-4 17 Jl 1937.

Weimer, J. L. Effect of the dwarf disease on the alfalfa plant. Jour. Agr. Res. 55: 87-104. f. 1-10. 15 Jl 1937.

Wells, B. W. Southern Appalachian grass balds. Jour. Elisha Mitchell Sci. Soc. 53: 1-26. pl. 1-5+f. 1, 13. Jl 1937.

Went, F. W. Salt accumulation and polar transport of plant hormones. Science II. 86: 127-128. f. 1. 6 Au 1937.

Werdermann, E. Borzicactus aurivillus (K. Schumann) Britton et Rose. Blüh. Sukkul. 31: pl. 122. 10 Ap 1937.

Werdermann, E. Cochemiea setispina (Coulter) Walton. Blüh. Sukkul. 32: pl. 126. 15 Je 1937.

Werdermann, E. Echinocereus pensilis (K. Branegee) J. A. Purpus. Blüh. Sukkul. 31: pl. 121. 10 Ap 1937.

Werdermann, E. Lemaireocereus Beneckei (Ehrenberg) Britton et Rose. Blüh. Sukkul. 32: pl. 125. 15 Je 1937.

Werdermann, E. Parodia aureispina Backeberg. Blüh. Sukkul. 32: pl. 127. 15 Je 1937.

Werdermann, E. Rebutia (Aylostera) pseudodeminuta Backeberg. Blüh. Sukkul. 32: pl. 128. 15 Je 1937.

Werdermann, E. Rebutia Marsoneri Werdermann. Blüh. Sukkul. 31: pl. 123. 10 Ap 1937.

Werdermann, E. Zwei seltene Cochemiea-Arten. Kakteenkunde 7: 105-108. illust. Jl 1937.

Wheeler, L. C. Euphorbia in the Pacific states. Bull. So. California Acad. Sci. 35: 127-147. My-Au 1936.

Wherry, E. T. A variety of *Phlox ovata* from the Alabama mountains. Bartonia 16: 112-120. pl. 2, 3. 1934.

Wherry, E. T. Synonyms and variety names for *Phlox nivalis*. Gard. Chron. Am. 41: 212-213. Jl 1937.

Wherry, E. T. The genus *Heuchera* in Virginia. Claytonia 4: 3-6. Jl. 1937.

Wherry, E. T. The Polemoniaceae of Pennsylvania. Proc. Pennsylvania Acad. Sci. 9: 150-155. f. 1, 2. 1935.

Whitaker, D. M. & Lowrance, E. W. The effect of hydrogen ion concentration upon the induction of polarity in *Fucus* eggs. Jour. Gen. Physiol. 21: 57-70. f. 1-3. 20 S 1937.

White, D. Fossil flora of the Wedington sandstone member of the Fayetteville shale. U. S. Dep. Int. Prof. Paper 186-B:

13-41. *pl.* 4-9. 1936.

- White, D. Fossil plants from the Stanley shale and Jackfork sandstone in southeastern Oklahoma and western Arkansas. U. S. Dep. Int. Prof. Paper 186-C: 43-67. pl. 10-14. 1936.
- Whitney, L. D. A new species of Hawaiian Eragrostis. Bernice P. Bishop Mus. Occ. Papers 13: 75-76. f. 1. 17 My 1937.
- Wiegand, K. M. & Weatherby, C. A. The nomenclature of the verticillate *Eupatoria*. Rhodora 39: 297-306. pl. 466-468. Au 1937.
- Williams, L. O. Orchid studies. I. Harvard Univ. Bot. Mus. Leafl. 5: 31-32. 1 Jl 1937.
- Williams, L. O. The Orchidaceae of the Rocky Mountains. Am. Midl. Nat. 18: 830-841. S 1937.
- Willison, R. S. Peach canker investigations. III. Further notes on incidence, contributing factors, and related phenomena. Canadian Jour. Res. 15: 324-339. f. 1-5. Jl 1937.
- Wilson, P. W. Symbiotic nitrogen-fixation by the Leguminosae. Bot. Rev. 3: 365-399. Au 1937.
- Winkler, A. J. & Shemsettin, E. M. Fruit-bud and flower formation in the Sultanina grape. Hilgardia 10: 589-610. pl. 1-5. My 1937.
- Woodcock, E. F. Vegetative anatomy of the tomato (Lycopersicum esculentum Mill.) II. Leaf structure. Papers Michigan Acad. Sci. 22: 235-242. pl. 28-30+f. 8. Je 1937.
- Woods, M. W. & Bamford, R. Chromosome morphology and number in *Tulipa*. Am. Jour. Bot. 24: 175-184. pl. 1, 2+f.1 Ap 1937.
- Yamamoto, Y. Species nova Mitrastemonacearum (Rafflesiaceaeum) ex Mexico. Bot. Mag. Tokyo 50: 539-541. f. 1-7. O 1936.
- Yarwood, C. E. Sulphur and rosin as downy mildew fungicides. Phytopathology 27: 931-941. f. 1, 2. S 1937.

CARRIED OVER FROM PREVIOUS ISSUE

- Rombouts, J. Algunas palavras sobre uma molestia cryptogamica, prejudicial aos tomateiros, na Bahia, causada por *Septoria lycopersici* Speg. Rodriguesia 2: 45-49. f. 1, 2. O 1937.
- Saeger, A. C. The concentration of copper in nutrient solutions for *Spirodela polyrrhiza*. Am. Jour. Bot. 24: 640-643. pl. 1. N 1937.
- St. John, H. & Fosberg, F. R. Vegetation of Flint Island, central Pacific. B. P. Bishop Mus. Occ. Papers 12²⁴. 1-4. 5 Ja 1937.
- St. John, H. & Warren, F. A. The plants of Mount Rainier National Park, Washington. Am. Midl. Nat. 18: 952-985. N 1937.
- Satina, S. & Blakeslee, A. F. Chromosome behavior in triploid Datura. II. The female gametophyte. Am. Jour. Bot. 24: 621-627. f. 1-16. N 1937.
- Schaffner, J. H. The fundamental nature of the flower. Bull. Torrey Club 64: 569-582. pl. 12, 13. 9 D 1937.
 - Scheer, B. A. Straight growth of the *Avena* coleoptile in relation to different concentrations of certain organic acids and their potassium salts. Am. Jour. Bot. 24: 559-565. f. 1-5. N 1937.
 - Schultes, R. E. Peyote (*Laphophora Williamsii*) and plants confused with it. Harvard Univ. Bot. Mus. Leafl. 5:61-88. f. 1, 2. 19 N 1937.
 - Schultz, E. S. Pathological phases of potato wart disease. Jour. Econ. Entom. 30: 721-723. O 1937.
 - Sharnel, A. D. A large-fruited bud mutation of the winter Nelis pear. Jour. Heredity 28: 351, 352. f. 10. O 1937.
 - Shreve, F. Lowland vegetation of Sinaloa. Bull. Torrey Club 64: 605-613. f. 1-3. 9 D 1937.
 - Shull, A. F. "Germ track" and "germ tract." Science II. 86: 440, 441. 12 N 1937.
 - Simmons, P. M. & Ledingham, R. J. A study of the fungous flora of wheat roots. Sci. Agr. Canada 18: 49-59. f. 1, 2. O 1937.
 - Small, J. K. Amsonia rigida. Addisonia 20: 25, 26. pl. 653 15 N 1937.
 - Smith, C. O. Inoculation of some economic plants with *Phyto-phthora cactorum* and *P. citrophthora*. Phytopathology 27: 1106–1109. f. 1. N 1937.
 - Smith, E. I. The induction period in photosynthesis. Jour. Genl. Physiol. 21: 151-163. f. 1-5. 20 N 1937.

Raymond H. Torrey

JAMES MURPHY

RAYMOND HEZEKIAH TORREY was born in Georgetown, Massachusetts, on July 15th, 1880. He died in New York City, July 15th, 1938, his 58th birthday. He was the son of Grafton F. Torrey and Leonora Warren, both of whom were born at Deer Isle, Maine.

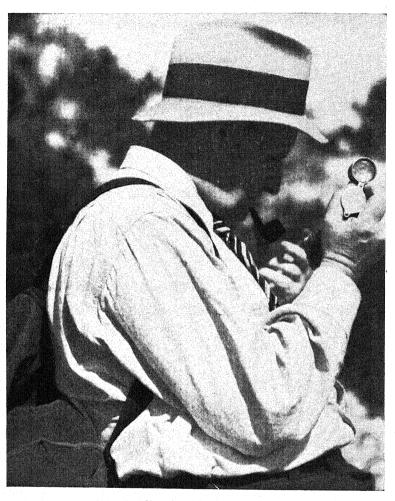
On his father's side he was related to John Torrey, the American botanist. His mother was a descendant of Richard Warren, who landed at Plymouth on the "Mayflower," and of General Joseph Warren, who was killed at Bunker Hill. His father and uncles were all seafaring men, and from them, as a boy, he heard many tales of adventure and distant places, which left a very vivid impress on his memory. He was a life member of the National Society of Puritan Descendants.

His early education was received in Georgetown. While in grammar school he became acquainted with Mr. and Mrs. Horner, local botanists, who were employed by Harvard College to collect specimens for use in classes in botany. Mr. Torrey frequently went with them after school and on weekends in search of specimens, and it became necessary in the pursuit of some rarer species to go even further and further afield due to their disappearance as a result of indiscriminate collecting. It was this fact that first directed Mr. Torrey's attention not only to tramping out-of-doors, but particularly to the urgency of the conservation and protection of our native flora. His interest in botany was further stimulated by his instructor in high school.

Upon graduation from the Georgetown High School in 1896, he obtained employment in the local newspaper, performing the varied tasks of editor, reporter, typesetter, and on occasion operated and even tended to and stoked the steam boiler which supplied the power. This journalistic experience, however, aided him in obtaining a position on the "Springfield Union." In 1903 he came to New York and entered the employ of the New York City News Association, as assistant to the night city editor and was later engaged by the "New York American" and "Herald Tribune." On the two latter papers he attained the position of Night City Editor. He conducted a column in the "New York Post" for many years, until his death, under "The Long Brown Path," which was devoted to life out-of-doors and to scientific aspects of nature.

His interest in botany led him to become a member of the Torrey Botanical Club which he did in 1920. The numerous articles and notes in "Torreya" attest to his enthusiasm for botany, and particularly to those

[The Bulletin for June (65: 347-432) was issued June 20, 1938]



Raymond H. Torrey

boreal plants found on high elevations throughout the club area, which are generally considered glacial relicts.

In his later years, due to the encouragement and inspiration of Dr. Alexander W. Evans, his interest was aroused in lichens, particularly the genus *Cladonia*, in which the club territory is particularly rich in species, forms and modifications. As the fruit of his travels and studies he contributed to "Torreya" an article "Cladoniae in the Range of the Torrey Botanical Club," which was profusely illustrated and constitutes the principal source of scientific knowledge and information on that subject available to those interested in the Cladoniae of this region. This was followed by other articles in "Torreya" on the same subject.

His native zeal and infectious enthusiasm stirred other students to an intensive pursuit of lichens generally, and particularly of the genus *Cladonia*. Prior to his death he had gathered together material for a memoir on the subject, with particular relation to the species *Cladonia Boryi* Tuck. which is found generally along the coast. The study was intended to embrace the area from Newfoundland to North Carolina as far as Nag's Head.

As a result of his apparently well-night indefatigable energy, as well as enthusiasm, he assembled probably the most complete herbarium of that genus in this part of the country, certainly the most complete in private possession.

He had been for sometime prior to his death the curator of the Cladoniae herbarium of the Sullivant Moss Society.

He eagerly looked forward to the time when he should be relieved of his other activities sufficiently to permit him to scientifically arrange the material collected and distribute it among those institutions which were interested therein. He had gathered together a library of practically all modern works on the subject, not only in English, but in French and German as well.

For the last eight years he was the chairman of the field committee of the Torrey Botanical Club, and the printed schedules of trips stand out as evidence of his devotion to outdoor botany. They have undoubtedly done much to maintain the tradition established and furthered by John Torrey and Nathaniel L. Britton.

Recognition of his efforts was manifested by his designation as a member of the Board of Managers of the New York Botanical Garden, and his election, this year, to the presidency of the Torrey Botanical Club.

While his work on Cladoniae has permanent scientific value, his efforts in the promotion of outdoor-life and conservation have contributed greatly not only to the enjoyment of many, but also to the future welfare of this country.

His alert mind and imagination being no doubt attracted by the natural beauty of the New England country-side, he spent much of his time traveling and in fact climbed to most of the important peaks. To facilitate the enjoyment of these natural beauties, he, in co-operation with others, laid out many trails, and particularly did he help in realizing the Appalachian trail from Mt. Katahdin in Maine to Mt. Oglethorpe in Georgia.

Naturally, his particular interest was directed towards the trails in New York City, in which city he spent his entire adult life. At the time of his death he was the chairman of the New York-New Jersey Trail Conference, and he was the editor of the "Guide to the Appalachian Trail," from the Housatonic to the Susquehanna Rivers.

In conjunction with Mr. Frank Place, Jr. and Dr. Robert L. Dickinson he was author of the "New York Walk Book." This publication was well received, and a new edition has been published by Dodd, Mead & Co., in 1934.

Some years prior to his death he gave up newspaper work, in which he had been actively engaged, except "The Long Brown Path," and became the secretary of the American Scenic Historic and Preservation Society and of the Society for the Preservation of the Adirondacks. This work gave him the opportunity, which he had long desired, of effectively advancing the cause of conservation, particularly in the eastern part of the United States. There came under his direct supervision and control such scenic and historic monuments as John Boyd Thacher Park in the Helderbergs, the Stony Point Reservation on the Hudson, Philipse Manor Hall, Letchworth Park, including Portage Falls on the Genesee River, Diamond Island in Lake George, Battle Island Park on Oswego River, and for a time, Watkins Glen in the Finger Lake Region of New York State.

He was above all devoted to the preservation of the Adirondacks, and particularly the lands that constitute the "Forest Preserve" of New York State, which under the State Constitution (Article 7, Section 7) "Shall be forever kept as wild forest lands." By reason of repeated attempts to encroach upon this preserve, Mr. Torrey was kept constantly on the alert in defense of the Forest Preserve. Just before his death, he was particularly concerned, by reason of the fact that a proposed new Constitution was being drawn for the State, and, to him, it was of the utmost importance that present Article 7 in Section 7 should not be thereby impaired or limited in its original scope and intention.

This work of Mr. Torrey's was what gave him the greatest inner satisfaction, since he felt that in protecting our natural heritage from the selfish exploitation by man, he was contributing not only to the preservation and furtherance of the health and spiritual uplift of his contemporaries, but also of those who would come after him, for he had found for himself in this changing and troubled world, in his communion with nature, that salvation for which man ever strives.

In addition to his daily contributions to the newspapers, Mr. Torrey wrote numerous articles of botanical historic, and scenic interest, and especially those concerned with conservation. (See bibliography).

Besides his widow, he left a married son, Raymond, a married daughter, Leonore Torrey Millett, a grandson, Warren Millett, a brother, Warren, of Revere, Massachusetts, and a sister, Mrs. Raymond Jackson, of Greystone Beach, Marblehead, Massachusetts.

Bibliography

- Another Catskill occurrence of Potentilla tridentata. Torreya 31: 146-147. 1931.
- Another report of Marchantia polymorpha after forest fires. Torreya **32**: 128–129, 1932.
- Azolla caroliniana survives in Queens kettle hole pond. Torreya **34:** 11-12. 1934.
- Cladoniae of the north woods. Torreya 34: 57-74. pl. 1-3. 1934.
- Cladoniae in the range of the Torrey Botanical Club. Torreya 33: 109-129. pl. 1-4. 1933.
- Collecting Cladoniae south of the Delaware capes. Castanea 2: 82-86. 1937.
- Contrasts between the Alpine floras of the eastern and western United States,
 - as observed by an amateur botanist. Jour. New York Bot. Gard. 28: 242–246. 1927.
- The Corema Conradii station on Shawangunk Mountain. Torreya 32: 97–100. illust. 1932.
- Dr. John Torrey in the Catskills. Torreya 32: 1-2. 1932.
- Fantastic frost crystals on dried stems of Dittany. Torreya 31: 10-12. illust. 1931.
- Fire Weeds. Torreya 33: 16. 1933.
- Fort Tryon Park. American Scenic and Historic Preservation Society. 1936.
- Frost Flowers reported 100 years ago. Torreya 31: 148-149. 1931.
- Hamilton Grange. American Scenic and Historic Preservation Society. 1934.
- Hottonia inflata in Harriman State Park. Torreya 30: 100. 1930.
- Interesting plants on the Appalachian trails on Kittatiny mountain, N.J. Torreva 29: 113-114. 1929.
- Lichens as relict species of the northward migration of plants since the close of the last glacial period. Bryologist 38: 3-8. 1935.

Lichens in your rock garden. Natural History. 41(4): 265-270. illust. 1938.

Lichens on old tombstones. Torreya 34: 96. 1934.

Marchantia polymorpha after forest fires. Torreya 32: 9-10. 1932.

More stations for Potentilla tridentata. Torreya 32: 159-161. 1932.

Nature trails at walking club camps. Torreya 27: 27-29. 1927.

New York Walk Book (with Frank Place and Robert L. Dickinson) new rev. ed. pp. 332. New York, Dodd, Mead & Co. 1934.

Only New Jersey stand of Sibbaldiopsis tridentata destroyed. Torreya 29: 72-73. 1929.

Paraphenylenediamine, a new color test for lichens. Torreya 35: 110-112.

Parmelia Cladonia, a beautiful northern lichen, found on Catskill summits. Torreya 33: 87–89. 1933.

Plant life around New York as studied by the Torrey Botanical Club. Jour. N. Y. Bot. Gard. 32: 141-145. 1931.

Potentilla (Sibbaldiopsis) tridentata survives on High Point. Torreya 30: 99. 1930.

The relation of the flora of the New Jersey pine barrens to the geological history of the region. Torreya 31: 169-173. 1931.

Rock tripes on a Long Island glacial boulder. Torreya 33: 63-64. 1933.

Sibbaldiopsis tridentata found in the Catskills. Torreya 30: 19-20. 1930.

State parks and recreational uses of state parks in the United States. pp. 259. Washington, D. C. 1926.

The survival and protection of harried flowers. Jour. N. Y. Bot. Gard. 27: 217-223. 1926.

Unusual plant occurrences around New York. Jour. N. Y. Bot. Gard. 31: 267–271. 1930.

Vagnera stellata growing in dune sand. Torreya 29: 114-115. 1929.

Vegetable, mineral or animal? Torreya 33: 8-14. 1933.

What will be the fate of Queens ponds? Torreya 29: 139-141. illust. 1929.

Potentilla tridentata on Schunemunk Mountain. Torreya 32: 9. 1932.

A large species of Rhizophidium from cooked beef

J. S. KARLING (WITH PLATES 20 AND 21)

In an experiment conducted to determine the host range of several species of Rhizophidium which occur on algae, flagellates, rotifers, etc., sterilized bits of ground beef were frequently used as one of the host media. Two of these chytrid species grew fairly well on this medium, and during the course of a study of their thalli a third member of the same genus appeared which at present seems to be different in many respects from any of the known species. With the infected bits of beef as a source of material I have been able to transfer this species to cooked filaments of Clado phora glomerata, Pitho phora sp., Nitella flexilis, Chara coronata and root tips of Allium cepa and Narcissus sp. All attempts to grow it on living cells have so far given only negative results. This is the first report in the literature of the occurrence of a species of Rhizophidium on cooked ground beef, and such a habitat seems at first to be rather striking and unusual. When it is recalled, however, that other species of the same genus have been reported from dead rotifers, various animal eggs, nematodes, etc., this occurrence appears less remarkable.

The present species is characterized structurally by unusually large thalli, sporangia, zoospores, and resting spores; and with the object of emphasizing these characteristics I am accordingly proposing the specific name macrosporum for it.

Rhizophidium macrosporum n. sp. Thalli eucarpic, numerous, gregarious. Zoosporangia hyaline, smooth, predominantly spherical 22–110 μ , oval, broadly pyriform, and urceolate with 1 to 5, usually 2 or 3, low inconspicuous exit papillae. Zoospores spherical 4.5—6 μ , hyaline, with an unusually large, 3–4 μ , clear refractive globule and a 25–35 μ long cilium; occasionally becoming amoeboid; initial swarmspores emerging in a small globular mass surrounded by a hyaline matrix and lying quiescent for a few moments before separating; the remainder becoming active within the sporangium and emerging usually one by one. Rhizoidal system usually extensively developed, coarse, and branched, main axis occasionally 6 μ in diameter; delimited from the sporangia by a cross wall at maturity; arising from a single point or rarely from several places at the base of the sporangium. Resting spores hyaline, smooth, spherical, 15–30 μ , oval, $18\times20-33\times36$ μ , or slightly irregular with a wall 1.5-2 μ thick, and one or more large refractive globules; germination unknown.

Saprophytic on cooked ground beef, dead cells of Cladophora glomerata, Pithophora sp., Nitella flexilis, Chara coronata and root tips of Allium cepa and Narcissus sp., in New York City.

STRUCTURE OF THE THALLUS

The thallus of R. macrosporum is usually very large and extensive. Figure 1 shows an exceptionally large individual from cooked beef with a sporangium which measured 105 μ in diameter and whose rhizoidal system extended 310 μ in a linear direction. It is thus obvious from this figure that species of Rhizophidium are not always small, but that their thalli may become as extensive as those of *Endochytrium*, *Diplophlyctis*, *Rhizophlyctis*, etc. The rhizoidal system of this species is usually richly branched with the extremities running out to fine tapering filaments and points. It usually arises at one point at the base of the sporangium or resting spores, as is shown in figures 1, 2, 3, 14, 15 and 16, but occasionally several axes may develop at separate regions on the base so that the sporangia become polyrhizoidal, figures 2, 4. Such thalli are doubtless formed from zoospores which develop more than one germ tube, as is suggested by figure 13. Sometimes the rhizoidal system consists of an elongated tapering tubular stalk or axis which branches extensively at its tip, so that the sporangia and resting spores become distinctly stalked, figures 3, 15. This stalk in exceptional cases may attain a diameter of 6 μ . In all thalli which I have been able to observe with clarity on bleached and semi-transparent host material the rhizoidal system was distinctly delimited from the sporangia by a cross wall.

The sporangia are usually sessile, but when they are crowded in groups some may stand off at varying distances from the surface of the host on the rhizoidal stalk. They may vary considerably in size, and as has been noted in the diagnosis given above the largest ones so far found on beef measured 110 μ in diameter. Other spherical ones have been observed on Cladophora glomerata and beef which measured only 22 and 23 μ respectively. The majority, however, are much larger according to present observations. Figures 2 and 4 show somewhat urn-shaped sporangia from Cladophora and Chara, while figure 3 illustrates one from Nitella. At maturity the refractive globules are so large and numerous that very little of the remaining protoplasm is visible in the sporangium, as is well shown in figures 1 to 4. The exit papillae are usually rather low and inconspicuous and vary from 1 to 5 in number. Usually only two or three are present and may be located apically or subapically.

The method of zoospore emission is similar to that of other species of *Rhizophidium* with the exception that the initial mass of emerged zoospores is usually rather small, and in the individuals separate and become motile very shortly. One or more of the exit papillae deliquesce at the same time, and a globule of hyaline fluid or slimy matrix issues forth. A few zoospores, 5–10, escape into this globule and lie quiescent for a few

moments. As the globule dissolves in the surrounding water the swarm-spores begin to separate and soon dart away. Others emerge successively, pause for a few seconds at the orifice, and then become actively motile. Sometimes the diameter of the orifice, may be smaller than that of the zoospores, so that the latter must elongate to emerge. As the pressure in the sporangium is apparently reduced those within begin to glide upon each other, and in a few seconds thereafter they are swarming violently inside of the sporangium. Those which fail to escape may remain motile for as long as two hours. Eventually they degenerate or germinate in situ. In some cases such trapped zoospores may increase markedly in size before germinating or disintegrating. Figure 9 shows such a zoospores which measured $12~\mu$ in diameter. Its refractive globule has also increased to a diameter of $10~\mu$. After the zoospores have escaped the sporangia may collapse partly and become greatly wrinkled.

As has been noted above the zoospores are hyaline and spherical, $4.5-6~\mu$, with a $25-35~\mu$ long posterior cilium. The refringent globule is frequently so large that it appears to constitute the major part of the spore. It is hyaline and refractive, and as the swarmspores become amoeboid and creep about in tight places it may undergo marked changes in shape, figures 6, 7, 8, showing that it is quite plastic in consistency. The motility of the zoospore is typical of other species of this genus. They dart about very quickly, come to rest momentarily, then dash away again. They may occasionally become amoeboid as is shown in figures 6, 7, 8, but this tendency is not as pronounced as in R. sphaerocarpum.

Germination of the swarmspores in water is not uncommon as is shown in figures 10, 11, and 13. The germ tube however, is not particularly thick for such large zoospores, according to present observations. Occasionally two and three tubes may develop, and such spores doubtless give rise to polyrhizoidal sporangia and resting spores. During the course of this study another smaller species of Rhizophidium, which is to be described below, infected the same host material, and the two were frequently found side by side. Inasmuch as the sporangia were often similar in appearance and the zoospores swarmed together, the suggestion immediately arose that I might be dealing with a heterothallis species with sporangia and motile gametes of marked difference in size. Careful watch was therefore kept for possible conjugation stages. Quite often the zoospores came to rest side by side, figure 13, but no fusion occurred. In other instances the germ tube of the smaller swarmspores was found growing towards the larger one as in figure 12. This suggested the possibility of fusion through a conjugation canal, but from careful observation of a number of such cases I am convinced that this orientation of the germ tube is merely fortuitous and of no significance sexually. The smaller zoospores doubtless relate to another species.

The development of the sporangia is not fundamentally different from that of other species of *Rhizophidium*, with the exception that the amount of refractive substance is more abundant. This was at first believed to be associated to some degree with the type of host medium used, but since the refractive globules are just as large when the sporangia occur on alga cells this is apparently not a vital factor.

RESTING SPORES

The resting spores of R. macrosporum have so far only been found on cooked and degenerating bits of beef. They are hyaline, smooth, predominantly spherical, 15–36 μ , and oval, 18×20 μ –33 \times 37 μ , but occasionally somewhat obpyriform, and irregular ones occur. They usually possess a very large refractive central globule, which in the largest spore so far found measured 30 μ in diameter. The large globule may often be surrounded by a number of smaller ones as is shown in figures 15 to 17. Occasionally two or more fairly large globules may be present, figure 15. The wall is not particularly heavy for spores of this size and does not usually exceed 2 μ in thickness. The spores are predominantly monorhizoidal, but sometimes stalked, figure 15, and polyrhizoidal ones occur, figure 17.

According to present observations these resting spores develop in the same manner as the evanescent zoosporangia up to a certain stage. After that they may usually be recognized by an abundance of large refringent globules as is shown in figure 14. With further development these apparently coalesce to form the large central one which is so characteristic of the mature spores, while the wall begins to thicken. So far no evidence of sexuality has been found in their development, nor has germination been observed.

Rhizophidium sp.—During the course of my study of R. macrosporum described above, another species of the same genus was found on dead rotifers, exuviae of various insects, and cysts of several unicellular algae which had been collected in a pond on Dr. R. A. Harper's farm near Ridgewood, N. J. In the shape of its sporangia and size of zoospores it may frequently resemble R. agile, R. gibbosum, and Phlyctochytrium bisporum.

This species was first observed on various dead animal and algal hosts, and with this as a source of material extensive cross inoculation experiments have been made to determine the range of host tissues upon which it will grow. It soon proved to be ubiquitous and capable of infecting and

growing saprophytically on a wide variety of material. Among plants it has been grown on killed cells of Cladophora glomerata, Pithophora sp., Oedogonium sp., Spirogyra crassa, Nitella flexilis, Chara coronata, Hydrodictyon reticulatum, and root tips of Allium cepa, Zea mays, Pisum sativum, Narcissus sp., Triticum sp., and Avena sativa. On root tips the thalli occur abundantly over the cap and formative region, and in heavily infected roots as many as 25 sporangia have been counted per sq. mm. of surface.

Among the algal and vegetable debris in which this chytrid occurred were numerous flagellates, rhizopods, rotifers, and other small animals. In the course of time many of these died and became infected. I have accordingly found it growing on dead individuals of *Phacus pleuronectes*, Euglena viridis, Arcella vulgaris, Arachnula sp., Difflugia urceolata, Centropyxis sp., Euglypha sp., Monostyla sp., and Distyla sp. Its occurrence on such a wide variety of animals suggested at once that it might be grown on other host material of this type. Dead ova and ovarian tissues of Fasciola hepatica were added to my cultures and became heavily infected within a few days. In two bits of material the ovarian tissue was completely overrun with thalli. I have also succeeded in growing it on dead eggs and young larvae of Drosophila melanogaster, dead abdominal tissues of cockroaches and thoroughly cooked striated muscle cells of beef. Its growth on the latter was limited and sparse, and the thalli did not appear until the beef had degenerated rather thoroughly.

Concurrently with these experiments involving dead plant and animal material attempts were also made to grow this chytrid on living algae and animal tissues. So far the results have been negative so I am inclined to regard this species as a saprophyte. It is to be noted here that Zopf described R. agile and R. gibbosum as virulent parasites which caused a marked degeneration of the chlorophyll and the remaining protoplasm. In this respect our species differs markedly from those of Zopf.

STRUCTURE OF THE THALLUS

This species is quite gregarious, and as many as 65 thalli have been counted on a single liver fluke ovum. On larger cells such as internodes of *Chara* and *Nitella* several hundred thalli in various stages of development may be present, while on root tips the cap and formative region may sometimes be almost completely covered. When a large number of thalli are grouped together in a localized region on a host cell, as is shown in figure 18, the sporangia are usually small and triangular or irregular in shape, doubtless partly as the result of mutual contact and pressure. Sometimes the sporangia do not rest directly on the surface of the host

cell but stand off at varying distances on the rhizoidal stalk or axis. In a few instances this extramatrical stalk has measured 10 to 15 μ in length.

This size to which the thallus may grow is illustrated in figure 19 of an isolated specimen growing on a thin, almost transparent strip of ovarian tissue of Fasciola hepatica. The rhizoidal system extended for a linear distance of 197 μ and consisted of a long stalk, 4 μ in diameter, which branched several times at its lower extremity. The sporangium measured 45 μ in diameter and is almost spherical in shape, with eleven exit papillae distributed rather evenly over its surface. This is one of the largest specimens I have so far found, and may be regarded as representing the upper limits. The lower limit in size is shown in figure 20. This sporangium is only 12 μ in diameter, while the rhizoidal system extends only about 25 μ in linear direction.

The main axis or stalk of the rhizoidal system when present may vary considerably in diameter and length. Occasionally it may be short, inflated, and apophysis-like, as in figures 21 and 31. When the thallus shown in figure 21 was first observed on Narcissus root tips I believed it related to a species of Phlyctochytrium, but as I followed it through to maturation and the emission of its zoospore I became convinced that it belonged to Rhizophidium sp. Such thalli according to present observations are comparatively rare, but they none the less show that species of Rhizophidium may occasionally resemble members of Phlyctochytrium in the character of the intramatrical rhizoidal system. A few thalli of this nature with small intramatrical, apophysis-like swellings on the rhizoidal system have also been reported by Zopf (1888, pl. 20, fig. 19) and Morini (1896, fig. 2) for R. gibbosum and R. messanense respectively.

The central stalk or axis may often be very short or lacking entirely, and in such cases a number of rhizoidal branches arise at the base of the sporangium as is shown in figures 24 and 30. These branches may often be very fine in the small thalli so as to form a brush-like tuft, while in the larger ones they may be relatively coarse.

The mature sporangia also vary considerably in shape and size. They may be almost spherical, $10-52~\mu$, slightly depressed, wedge-shaped and somewhat triangular, $14\times29~\mu-25\times30~\mu$, oval and occasionally slightly irregular. The exit papillae are usually very low and vary from 1 to 11 in number. Sporangia with a single papilla as well as those with a high number are comparatively rare. Two to four appear to be the most common numbers according to present observations. The highest number of papillae usually but not always occur on the larger sporangia. The orifices for the emission of the zoospores vary from 3 to 5 μ in diameter and are usually slightly oval or spherical.

In mounting the host tissue for study sporangia often break away from the rhizoidal system and lie free in the surrounding water. Occasionally the main rhizoidal axis or stalk accompanies them, figure 33. These sporangia are quite normal in appearance, and if mature they may undergo cleavage and emit their zoospores in the usual manner. Their ability to break away and develop thus is doubtless due to the fact that they are delimited from the rhizoidal system by a cross wall.

At maturity the protoplasm of the sporangia is relatively homogeneous optically, except for a great number of minute globules which do not appear to be refringent as those of other Rhizophidium species. This difference may be due largely to their small size, since they usually measure less than 1 μ in diameter. Figure 22 shows the appearance of a sporangium with two subapical exit papillae approximately two hours before dehiscence began. Whether or not cleavage has occurred is not certain, but the limits of the individual zoospores are not yet visible. A short while before the sporangium opens, however, the lines of demarcation usually become quite distinct. Often the distinction may become as clear and sharp as Couch (figs. 59, 60) has shown in P. bisporum. Since the thalli occur in such great abundance it is not difficult to find sporangia in all stages of dehiscence. Several exit papillae may deliquesce at the same time, so that the swarmspores may be seen emerging at several places on the sporangium. Sometimes they emerge one by one, become momentarily amoeboid and swim directly away, figure 23. In other cases a number of spores may emerge in a small globular mass surrounded by a hyaline matrix and lie quiescent for a few moments before loosening up and moving apart, figure 24. From present observations I believe the latter type of behavior is the more normal and usual for the very large sporangia of this species. Numerous factors, however, such as unfavorable environmental conditions, premature deliquescence of the exit papillae etc., undoubtedly influence the process and lead to variations. I have not so far observed the initial globular mass of extruded zoospores to become as large and conspicuous as Zopf describes for R. sphaerocarpum. This may perhaps be due in part to a difference in viscidity of the surrounding matrix. After a considerable number of zoospores have emerged the pressure in the sporangium is apparently reduced, so that the remaining spores soon become active. They first begin to glide slowly upon each other, but after a few seconds they attain such motility that the sporangium becomes a mass of seething and darting spores. These then emerge one by one, in twos, or in threes. By observing only this stage one might readily get the impression that it constitutes an initial stage of zoospore emission. The length of time required for total emission is rather short, varying from

50 to 200 seconds, according to the size of the sporangium. Occasionally a number of zoospores may fail to escape and these either degenerate or germinate in situ. The empty sporangium usually becomes somewhat shriveled and wrinkled, and may often take on a yellowish brown tinge with age. Extensive tests with chloroiodide of zinc on the walls have so far failed to give any cellulose reaction. This is in marked contrast to R. agile, whose sporangial walls Zopf describes as being composed of cellulose.

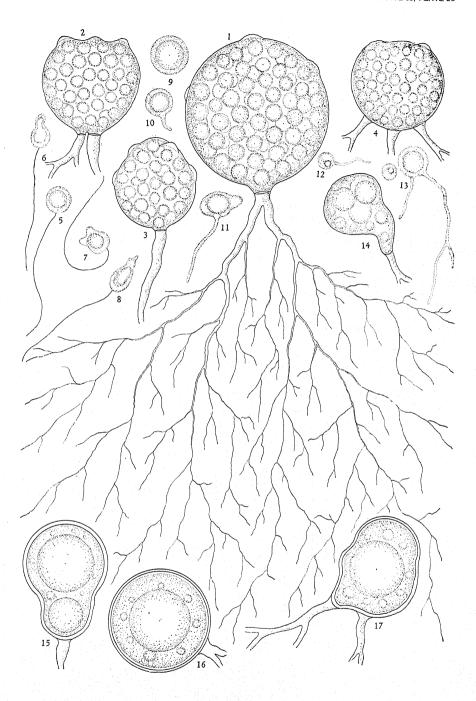
The zoospores, figure 26, are hyaline, spherical, $2.5-3~\mu$ in diameter with a small refractive globule usually lying in the posterior region. The cilium is approximately $25~\mu$ in length. The swarmspores dart about with great rapidity, and may remain actively motile for more than half an hour. They may occasionally become amoeboid, figure 25, but this is not nearly as marked as in R. sphaerocarpum. Germination occurs quite frequently in water, figures 27-29, and often more than one germ tube may develop. During germination the zoospore becomes vacuolated, and the refractive globule is thus displaced towards the periphery, figure 29.

The further development of the thallus is fundamentally similar to that of other species of *Rhizophidium*. After the germ tube has branched to form the rudiments of the rhizoidal system, and the latter has become somewhat extended, the zoospore begins to enlarge into an incipient sporangium. Figure 30 shows a very early stage in which the young spo-

Explanation of Plate 20

Rhizophidium macrosporum n. sp.

- Fig. 1. A large thallus from cooked beef with an extended rhizoidal system and a spherical zoosporangium filled with large refractive globules.
- Fig. 2. Smaller urn-shaped sporangium with three exit papillae and two main rhizoidal axes.
 - Fig. 3. A stalked sporangium with four exit papillae.
 - Fig. 4. A small sporangium with three separated rhizoidal axes.
 - Fig. 5. A zoospore showing the unusually large refractive globule.
- Figs. 6–8. Amoeboid zoospores showing the changes in shape undergone by the refractive globule during amoeboid movement.
- Fig. 9. A quiescent, greatly expanded zoospore which failed to emerge from the sporangium.
 - Figs. 10,11. Early germination stages.
- Fig. 12. Germination of a zoospore of *Rhizophidium* sp., with the germ tube directed towards a swarmspore of *R. macrosporum*.
- Fig. 13. A zoospore of *Rhizophidium* sp. lying close to a germinating swarmspore of *R. macrosporum*.
 - Fig. 14. An early stage of resting spore development.
 - Figs. 15-17. Variations in the size and shape of the resting spores.



KARLING: RHIZOPHIDIUM

rangium is quite vacuolated. This condition appears to be characteristic of the early developmental stages, as Couch (figs. 54, 55) has shown for *P. bisporum* also. Furthermore, the remainder of the protoplasm is rather pearly opaque and not as refringent as I have observed it in other species. In figure 31 is shown a half grown sporangium with three conspicuous vacuoles. One of them contains a dark globule which showed striking Brownian movement. This sporangium was kept under observation for a long time, and during this period the three vacuoles were continually changing in shape and position, indicating a definite circulation or movement of the protoplasm. Eventually these vacuoles fused into a large central one, as is illustrated in the sporangium of figure 32. As the sporangia increase in size and mature the vacuolate condition gradually disappears. The movement and fusion of the vacuoles described above are the only unusual characteristics I have observed in the development of the sporangia.

As has been stated above no resting spores were found on any of the host material employed. In two instances a light brown, thick-walled, spherical, 9 μ resting spore with a large, 5 μ refringent globule in the center and a long hyaline, attached, haustorium-like peg was observed, but I am not certain that it relates to our species. It is to be noted in this connection that Zopf and Couch also failed to find the resting spores of R. agile, R. gibbosum and P. bisporum in spite of repeated search over a long period of

Explanation of Plate 21

Rhizophidium sp.

Fig. 18. A group of stalked, somewhat triangular-shaped sporangia on the surface of a liver fluke ovum.

Fig. 19. A large thallus on the ovarian tissue of Hepatica fasciola.

Fig. 20. A minute thallus drawn for comparison with the one shown in fig. 19.

Fig. 21. A portion of a thallus from root tips of *Narcissus* showing the inflated, apophysis-like rhizoidal stalk.

Fig. 22. A sporangium with two exit papillae shortly before cleavage.

Fig. 23. An initial stage in the emergence of the zoospores.

Fig. 24. Emergence of the zoospores from a large sporangium.

Fig. 25. An amoeboid zoospore.

Fig. 26. A zoospore during the active swimming stage.

Figs. 27-29. Germination stages.

Figs. 30-32. Stages in the development of the zoosporangium.

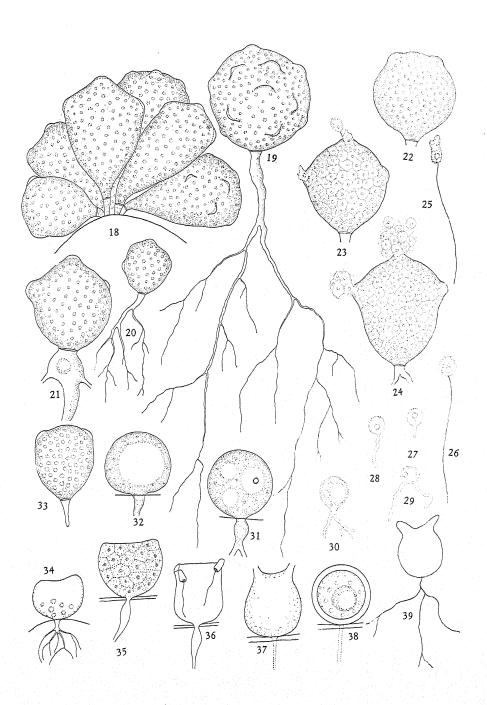
Fig. 33. A small free-floating sporangium with two exit papillae.

Fig. 34. A small sporangium of R. agile after Zopf.

Figs. 35, 36. Sporangia of Phlyctochytrium bisporum after Couch.

Figs. 37, 38. A sporangium and resting spore of P. bisporum after Sparrow.

Fig. 39. A thallus of R. rostellatum after de Wildeman.



KARLING: RHIZOPHIDIUM

time. Whether or not this may indicate a possible relationship or identity of these species with ours is of course a matter of speculation.

DISCUSSION

As has been noted above the small sporangia of Rhizophidium sp. frequently bears considerable resemblance to those of R. agile, R. gibbosum, R. rostellatum, and Phlyctochytrium bisporum. With the view of presenting these similarities more concisely I have brought together in figures 34 to 39 thalli of these species as they have been illustrated by Zopf, Couch. Sparrow and de Wildeman. This is, of course, a selected group of drawings and shows only the thalli which are similar as to shape. Rhizophidium agile was described by Zopf (1888) and Serbinow (1907) on Chroococcus turgida, and is characterized by small, 10–15 μ , slightly triangular sporangia with an apical exit papilla, minute, 2.5 μ , zoospores, and a virulently parasitic nature. The smallest sporangia of our species fall within the size magnitude of those of R. agile, but the largest ones may be five times as great in diameter. Furthermore, as many as 11 exit papillae may occasionally be present on such sporangia, giving them a distinct gibbose appearance. In this respect they may frequently resemble some of the sporangia of R. gibbosum Zopf (1888) on species of Cylindrocystis, Phycastrum and Penium. The zoospores of R. gibbosum are similar to those of our species in size, behavior, and general appearance, but the sporangia have only a single functional apical papilla, according to Zopf.

The sporangia, zoospores and rhizoidal system of our species are also often very similar to those of Phlyctochytrium bisporum described by Couch (1932) and Sparrow (1933, 1936) on Vaucheria, Oedogonium, Bumilleria and Spirogyra. This species is characterized by small, 8-13 μ , sporangia with two exit papillae or orifices near the apex which give them a somewhat triangular shape, figures 35-37, an occasionally inflated rhizoidal stalk, and zoospores which measure 2.6–3 μ in diameter. A comparison of Couch's and Sparrow's drawings with my figures 18, 22, 23, 24 and 33 show a striking similarity in shape relative to the smaller sporangia. A further similarity is suggested by Couch's report that his species usually grows on the disorganized cells of the host, which indicates that it may be largely saprophytic. Couch failed to observe the resting spores, but Sparrow (1936) found hyaline, spherical, thick-walled spores, figure 38, associated with the sporangia which he believes may belong to P. bisporum. He further believes that Couch's species is the same as R. rotellatum (de Wildeman) Fischer which occurs on Spirogyra crassa. Figure 39 shows a thallus of the latter species as drawn by de Wildeman and in the presence of the two horn-like exit papillae it is very similar to Sparrow's drawing, figure 37, of P. bisporum.

The occasional similarities in size and shape of the sporangia and zoospores of our chytrid with those listed above may indicate a close relationship of these species, but until more is known about them, it is impossible to determine whether or not they are identical. Characters such as size and appearance of sporangia, number of exit papillae, etc., are often highly variable and, within certain limits, of doubtful diagnostic value, so that too much significance must not be attached to them. Accordingly, in view of the fact that I have so far failed to find the resting spores in *Rhizophidium* sp., I shall for the time being leave it unidentified. I am none the less continuing my study on it with the hopes of observing its complete life cycle.

The present study shows how ubiquitous and large species of *Rhizo-phidium* may be. The majority of species are described in the literature as being comparatively small and parasitic or weakly saprophytic. *Rhizophidium macrosporum* and *Rhizophidium* sp., appear at present to be primarily saprophytic and capable of growing on a wide variety of dead animal and plant tissues. Furthermore, in the former species the thalli may attain the size of species of *Entophlyctis*, *Endochytrium*, *Diplophlyctis*, etc. Doubtless as more intensive studies of individual species are made, we shall find an even greater variability in size and host range.

SUMMARY

Rhizophidium macrosporum was first observed on cooked ground beef, and has subsequently been grown on various sterilized filamentous algae and root tips. It is characterized by large spherical (22–110 μ) oval and broadly pyriform, hyaline, smooth sporangia, spherical (4.5–6 μ) zoospores with an unusually large refractive globule, a coarse extensive rhizoidal system, and large spherical (15–30 μ) or oval (18×20–22×37 μ) hyaline resting spores.

Rhizophidium sp. occurs saprophytically on a wide variety of dead filamentous and unicellular algae, flagellates, rhizopods, rotifers, liver fluke ova and ovarian tissue, eggs, larvae and exuviae of insects, cooked striated muscle cells and root tips of various plants. The sporangia may be almost spherical $(10-52~\mu)$, slightly depressed, wedge-shaped and somewhat triangular $(14\times29~\mu-25\times30~\mu)$ oval and occasionally slightly irregular with 1 to 11 exit papillae. The smaller sporangia may often resemble those of R. agile, R. gibbosum, R. rostellatum and Phlyctochytrium bisporum. Resting spores have so far not been found.

Literature cited

Couch, J. N. 1932. Rhizophidium, Phlycotochytrium and Phlyctidium in the United States. Jour. Elisha Mitchell Sci. Soc. 47: 245-260.

- Serbinow, J. S. 1907. Beiträge zur Kenntniss der Phycomyceten. Scripta Bot. Horti. Univ. Imp. Petrop. 24: 149-173.
- Sparrow, F. K. 1933. Inoperculate chytridiaceous organisms collected in the vicinity of Ithaca, N. Y., with notes on other aquatic fungi. Mycologia 25: 513-535.
- -----. 1936. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. Jour. Linn. Soc.-Bot. 50: 417-478.
- Wildeman, E. de. 1890. Chytridiacees de Belgique. Ann. Soc. Belge Micro. 14: 1-28.
- Zopf, W. 1888. Zur Kenntniss des Infections-Krankheiten niederer Thiere und Pflanzen. Nova Acata Ksl. Leop.—Carol. Deut. Akad. Nat. 52: 313-376.

Thiamin and growth of Pythium Butleri

WILLIAM J. ROBBINS AND FREDERICK KAVANAGH
(WITH THREE FIGURES)

Studies on the relation of thiamin (vitamin B_1) to the growth of fungi have shown that on the basis of our present knowledge they may be arranged in at least three groups.

GROUP I includes those which synthesize thiamin from the elementary materials of the medium and require for growth no external supply of thiamin or its intermediates. The growth of some of these plants is not materially affected by the addition of thiamin to the medium; that of others is inhibited by its addition (3).

GROUP II includes those which do not synthesize thiamin or its intermediates from the constituents of the medium. Some of these are incapable of forming thiamin from the thiazole and pyrimidine intermediates; for growth to occur they require an external supply of the vitamin as such (4, 5). Others are capable of forming the vitamin from the intermediate thiazole and pyrimidine, but are incapable of synthesizing the intermediates themselves. These plants require for growth an external supply of thiamin or of both intermediates (2, 7, 8, 9).

GROUP III includes those which do not synthesize thiamin but are able to form one or the other of the vitamin intermediates. Some form pyrimidine; these grow if furnished with thiamin or with the vitamin thiazole (1); others form thiazole and grow if supplied with thiamin or the vitamin pyrimidine (3, 10).

Pythium Butleri Subramanian differs somewhat from all the types described above. Under certain conditions this organism appears to form thiamin but in amounts inadequate for maximum growth; under other conditions it forms little or no thiamin. In either instance the addition of thiamin or of pyrimidine increases the rate of growth. In its ability to grow in media containing no growth supplement it resembles the organisms of Group III.

METHODS AND MATERIALS

The culture of *Pythium Butleri* was furnished by J. T. Middleton. Stock cultures were maintained on potato dextrose agar.

Several nutrient solutions were used as follows:

SOLUTION D, containing about 16.4 g. of salts per liter, was composed of MgSO₄·7H₂O, 5.0 g.; KH₂PO₄, 10.32 g.; Na₂HPO₄, 0.575 g.; NH₄NO₃, 0.5.; asparagine, 5.0 g.: dextrose (cerelose), 50.0 g. and redistilled water, 1000 cc. To each liter of the above solution 1 ml. of a modified Hoagland's

A to Z mixture (3) was added. The hydrion concentration was pH 5.5.

Solution E, containing about 1.64 g. of salts per liter, was made by diluting the salts and asparagine of solution D ten times and reducing the dextrose to 20 g. per liter.

Solution G, containing about 1.64 g. of salts per liter, was made by diluting the salts of solution D ten times but maintaining the asparagine and dextrose concentrations unchanged.

SOLUTION I contained no organic nitrogen. It was composed of MgSO₄·7H₂O, 0.25 g.; KH₂PO₄, 0.5 g.; NH₄NO₈, 1.0 g.; KNO₃, 1.0 g.; dextrose, 25.0 g. and redistilled water 1000 cc. To each liter of this solution 1 ml. of a mixture of Steinberg's mineral supplements (4) was added.

The thiamin chloride used was a crystalline product (betabion) from Merck and Co. The thiamin intermediates, supplied through the courtesy of Merck and Co., were 2-methyl-5-bromomethyl-6-amino pyrimidine hydrobromide, 2 methyl-5-ethoxymethyl-6-amino pyrimidine, and 4-methyl-5 β -hydroxyethyl thiazole. For brevity the first mentioned pyrimidine and the thiazole are referred to in this paper as pyrimidine and thiazole respectively.

The asparagine was repurified by solution in water and precipitation with alcohol for all experiments except those with solution D. The dextrose was a sample of high purity (cerelose) from the Corn Products Co.

The solutions were sterilized at 12 lbs. pressure for 20 minutes. In some instances the thiamin was filtered sterile and added to the basic nutrient solutions which had been sterilized by heating.

The *Pythium* was grown at room temperature (20–25°C) in 25 ml. of solution in 125 ml. flasks of pyrex glass. The solution in the flask was inoculated by transferring a bit of mycelium from the stock cultures. In making inoculations care was used to avoid transferring any of the medium in which the inoculum had grown. All cultures were grown in triplicate.

Dry weights were determined by washing the mycelium with water to remove the sugar and drying at 100°C. Some difficulty was experienced in washing the mycelium free of sugar, and the dry weights in the earlier experiments were influenced to some extent by residual sugar.

EXPERIMENTAL

Solution D.—P. Butleri grew very poorly in solution D forming but 4 mg. of dry mycelium in 19 days. The addition of 3 units of thiamin increased the growth more than 70 times (table 1). The addition of thiazole alone had little effect but pyrimidine alone was quite effective. A mixture of thiazole and pyrmidine increased growth but much less

¹ A unit is 10⁻⁹ Mole of the compound.

than molecularly equivalent amounts of thiamin. The effects of supplementing solution D with thiamin or its intermediates on the growth of *P. Butleri* are shown in figure 1.

We are uncertain as to how much reliance should be placed on the differences in dry weights in the solutions supplemented with thiamin, pyrimidine and the mixtures of thiazole and pyrimidine. It would seem from the photographs taken at the end of 14 days incubation (fig. 1) and the dry weights determined after 19 days growth (table 1) that thiamin

TABLE 1

Dry weight of mycelium of Pythium Butleri grown 19 days in solution D, 14 days in solution G or 19 days in solution I and in the same solutions supplemented with thiamin or its intermediates

SUPPLEMENT	DRY WT. MG. MYCELIUM SOLUTION D	DRY WT. MG. MYCELIUM SOLUTION G	SUPPLEMENT	DRY WT. MG MYCELIUM SOLUTION I
None	4	149 ± 21	None	39±4
3 units thiamin	285±15	168 ± 10	5 units thiamin	110±4
30 units thiamin	305±5	210±3	5 units thiazole	73±9
3 units thiazole	13	169	5 units pyrimidine	103±3
30 units thiazole	26±33	180 ± 4	5 units thiazole and	94±9
3 units pyrimidine	249 ± 32	236±11	5 units pyrimidine	
30 units pyrimidine	230±25	293 ± 7	dextrose only no salts	0.6
3 units thiazole and 3 units pyrimidine	23	266 ± 27		
30 units thiazole and 30 units pyrimidine	135±15	305 ± 10		

was more effective in solution D than either pyrimidine alone or the mixture of thiazole and pyrimidine. It would appear also that the mixture of thiazole and pyrimidine was less effective than molecularly equivalent quantities of pyrimidine. Before such conclusions can be drawn additional experiments with solution D should be performed; uniformity in inoculations with this organism is difficult to secure. Furthermore, the time factor is important as may be noted by comparing the relative growth of the fungus in the solutions supplemented with thiamin and its intermediates as shown in the photograph taken after 14 days growth and the relative dry weights formed at the end of 19 days. In any event the beneficial

effect of the additions of thiamin and of pyrimidine to the medium were clear.

During the course of this experiment the growth in one of the flasks supplemented with 3 units of pyrimidine was observed to be considerably heavier than that in the other two. Microscopic examination showed contamination by a rod shaped bacterium in this flask. It is probable that thiamin formed by the contaminating organism was responsible for the more rapid growth of *Pythium* in the contaminated culture (fig. 2).

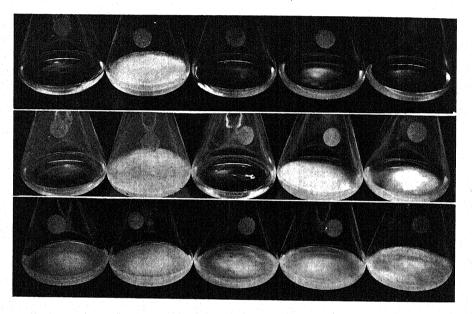


Fig. 1. Growth of *Pythium Butleri* in solutions supplemented with thiamin or its intermediates. Above, solution D with 3 units of supplements; center, solution D with 30 units of supplements; below, solution E with 30 units of supplements. In each series from left to right; no supplement, thiamin, thiazole, pyrimidine, thiazole and pyrimidine. Period of growth 14 days.

It would seem from the results with solution D that P. Butleri belongs with those organisms described above in Group III which grew satisfactorily with the addition to the basic medium of either thiamin or the intermediate pyrimidine. However, when solution D was diluted differences in the response of this fungus and those mentioned earlier became apparent.

Solution E.—P. Butleri grew in solution E without the addition of any supplement (fig. 1). In 19 days it formed 45 mg. of dry mycelium under the same conditions in which it formed but 4 mg. in solution D. To eliminate the possibility that this growth was made at the expense of

thiamin carried over in the inoculum a subculture was made from the growth in solution E to a fresh lot of the same solution. In 19 days mycelium of 68 mg. dry weight was produced. A third transfer yielded 76 mg. in 14 days. *P. Butleri* appeared to be capable of growing indefinitely in a suitable solution to which no supplement had been added.

The addition of 3 units or of 30 units of thiamin to solution E increased the growth, the effect showing more sharply in the early stages of development than later. However, much less mycelium developed in solution E in the presence of thiamin than in solution D, which was taken to indicate that some factor (probably the nitrogen content) limited growth in the former medium. To obviate this difficulty solution G was used.

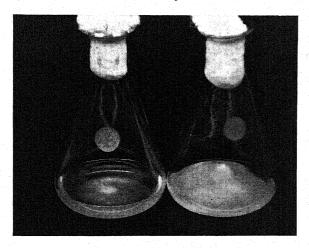


Fig. 2. Effect of contaminating bacteria on growth of *P. Butleri* in solution D plus 3 units pyrimidine. Left, uncontaminated; right, contaminated. Period of growth 14 days.

Solution G.—In this solution (table 1) *P. Butleri* formed 149 mg. of dry mycenum in 14 days. The addition to solution G of thiamin, of pyrimidine, or of the mixture of thiazole and pyrimidine increased the growth. Thiazole alone had little effect. From three to four times as much mycelium was formed in solution G as was produced in the same time in solution E. This was interpreted to be the result of the greater amount of asparagine and dextrose furnished in solution G.

Solutions D, E, and G contained asparagine which is an organic substance of natural origin. In order to eliminate the asparagine as a complicating factor a solution was used containing no nitrogen other than inorganic nitrogen.

SOLUTION I.—P. Butleri grew slowly in solution I forming a mycelium

of 39 mg. in 19 days. A subculture from this solution to more of the same medium yielded 120 mg. in 26 days; a third, fourth and fifth successive transfer to solution I was made with no evident diminution in the rate

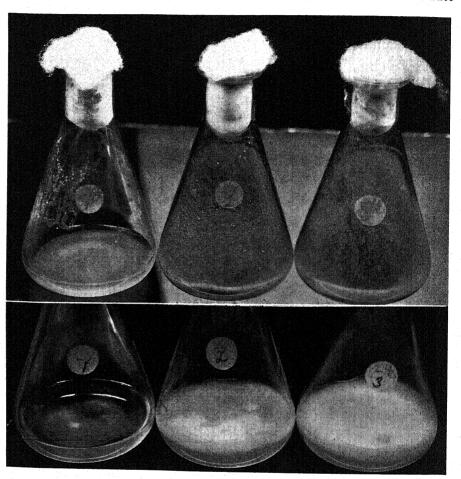


Fig. 3. Formation of thiazole by *P. Butleri*. Below from left to right, solution D plus thiazole, plus pyrimidine, plus thiazole and pyrimidine. Above, same solutions sterilized, mycelium removed and inoculated with *Phycomyces Blakesleeanus*.

of growth. These results indicate that this fungus is capable of unlimited growth in a mineral solution containing dextrose.

The addition of thiamin, of ethoxypyrimidine or of thiazole and pyrimidine to solution I increased the growth of *P. Butleri* (table 1), each of the compounds or combination of compounds being nearly equally effective. Thiazole produced a small increase.

Formation of thiamin and intermediates by P. Butleri.—The results

given above show that the growth of P. Butleri in the solutions used was improved by the addition of thiamin or of pyrimidine. The effect of thiazole was less marked. How should these results be interpreted? Does the fungus require thiamin forming some, though insufficient for maximum growth, in the unsupplemented solutions and synthesizing thiazole in the solutions supplemented with pyrimidine? Or does it require pyrimidine only, synthesizing small quantities in the unsupplemented solutions and securing the necessary amount in the thiamin cultures by splitting the vitamin into its thizaole and pyrimidine constituents? We have no direct evidence to show the need for thiamin as such, though we are inclined to believe that the organism requires the vitamin rather than the intermediates. We have evidence, however, that in the thiazole solutions P. Butleri forms some pyrimidine and in the pyrimidine cultures it forms considerable thiazole. In other words. P. Butleri requires both intermediates for growth forming thiazole more readily than pyrimidine. The evidence upon which this conclusion is based is as follows:

P. Butleri was grown in solution D supplemented with 30 units of thiazole, 30 units of pyrimidine or 30 units of both intermediates. The growth in the thiazole solutions was slight; it was considerably heavier in the solutions containing pyrimidine or both intermediates (see fig. 3). At the end of 19 days the mycelium of P. Butleri was removed, the solutions sterilized and inoculated with Phycomyces Blakesleeanus. This fungus has been demonstrated to require for growth an external supply of thiamin or of both intermediates. At the end of twelve days Phycomyces had produced some submersed mycelium in the solution originally supplemented with thiazole only, indicating the formation of a small quantity of pyrimidine. In the solution originally supplemented with pyrimidine only there was a heavy development of aerial mycelium with sporangia and sporangiophores showing the formation of 3 units of thizaole or more. These results indicate that P. Butleri requires both intermediates for growth and synthesizes more thiazole than pyrimidine.

DISCUSSION

We have interpreted the results of the experiments described above to mean that *P. Butleri* requires thiamin for growth, in the more dilute solutions used (solutions E, G and I) the fungus synthesized from the more elementary constituents of the medium sufficient vitamin for slow growth but insufficient for maximum growth. In other words, in these solutions the amount of thiamin formed by the organism was the factor limiting growth. Judging from the effect when pyrimidine alone was used as a supplement it would seem that a slow formation by the organism of

the pyrimidine portion of the vitamin molecule was the limiting factor in solutions E, G, and I.

On the basis of the above interpretation we would explain the failure of P. Butleri to grow in solution D as follows: In this solution the total salt concentration or concentration of some particular salt interferred with the synthesis of thiamin. The assumption that the salt concentration interferred with thiamin synthesis rather than the functioning of the vitamin would seem to follow since the addition of thiamin to solution D markedly improved the growth; it was effective if present. We cannot say definitely whether the salt concentration interferred with the synthesis of the intermediates by P. Butleri or the synthesis of thiamin from the intermediates. The latter would be suggested by the relatively poorer growth in the solution D supplemented with thiazole and pyrimidine than in the same solution supplemented with thiamin. This difference did not appear in the more dilute solutions (solutions G and I, table 1). However, the salt concentration appeared to interfere with the formation of the pyrimidine portion of the vitamin more than it did with the thiazole portion. This follows because growth in solution D supplemented with thiazole alone was much less, relative to that in the same solution supplemented with thiamin or with pyrimidine, than in the more dilute solution G (table 1).

The beneficial effect on the growth of *P. Butleri* of the dilution of solution D and of the addition of thiamin to the same solution is similar to the results reported by Seager (6) for *Lemna*. Seager observed that *Lemna* did not grow indefinitely in Knop's solution. The addition of dried yeast to Knop's solution or the dilution of the solution to 1/10 its normal strength permitted growth to occur, although even in the dilute Knop's solution the addition of yeast was beneficial.

The response of *P. Butleri* to thiamin and its intermediates is of particular interest because it shows that salt concentrations may injure a plant because of its effect upon thiamin production. Why should this be true of *P. Butleri* and not of *Aspergillus niger* which grows well in solution D? Furthermore, other organisms which have been reported incapable of synthesizing thiamin should be tested in various solutions and conditions since the formation of thiamin by *P. Butleri* was influenced by the conditions (mineral salt concentration) of culture.

SUMMARY

The growth of *Pythium Butleri* in a mineral salt solution containing asparagine and sugar (solution D) was negligible. The addition of thiamin or the vitamin pyrimidine markedly increased the growth.

P. Butleri was capable of unlimited growth when the salts of solution D were diluted; growth was increased in this solution by the addition of thiamin or pyrimidine.

Contaminating bacteria in one instance increased growth of P. Butleri.

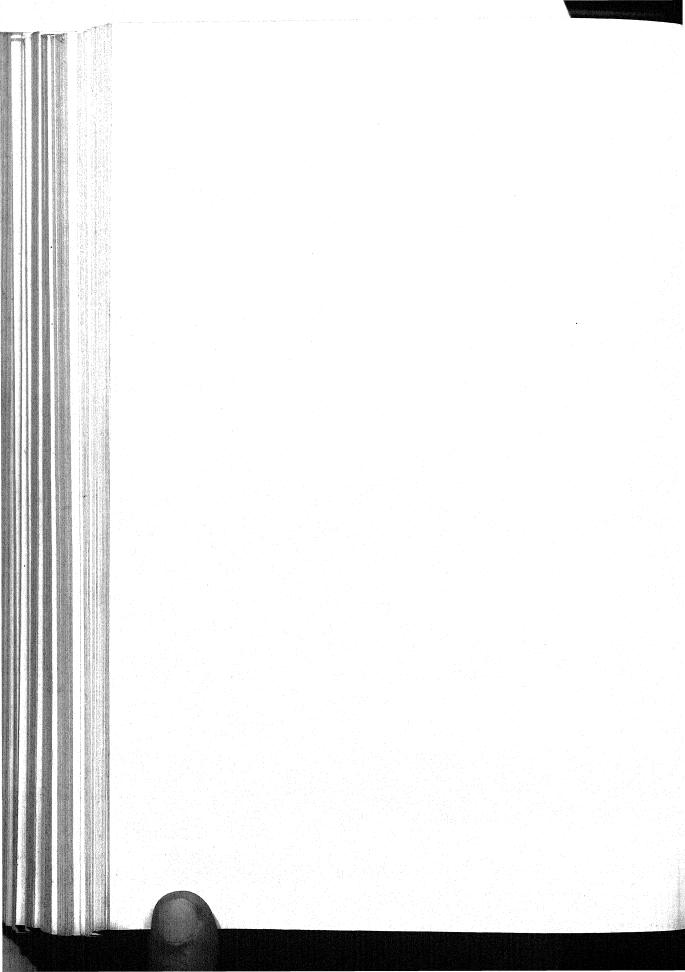
The formation of thiazole and of smaller amounts of pyrimidine was demonstrated.

It is concluded that under the conditions of these experiments the growth of P. Butleri was limited by its thiamin production which was affected by the concentration of salts in the solution.

THE NEW YORK BOTANICAL GARDEN

Literature cited

- Müller, Werner et William Henri Schopfer. 1937. L'action de l'aneurine et de ses constituants sur Mucor Ramannianus Möll. Compt. Rend. Acad. Sci. Paris 205: 687-689.
- 2. Robbins, William J. and Frederick Kavanagh. 1937. Intermediates of vitamin B₁ and growth of *Phycomyces*. Proc. Nat. Acad. Sci. 23: 499–502.
- 3. Robbins, William J. and Frederick Kavanagh. 1938. Vitamin B₁ or its intermediates and growth of certain fungi. Am. Jour. Bot. 25: 229-236.
- Robbins, William J. 1938. Thiamin and growth of species of Phytophthora. Bull. Torrey Bot. Club. 65: 267-276.
- Robbins, William J. 1938. Organisms requiring vitamin B₁ Proc. Nat. Acad. Sci. 24: 53-56.
- 6. Saeger, Albert. 1925. The growth of duck weeds in mineral nutrient solutions with and without organic extracts. Jour. Gen. Physiol. 7: 517-526.
- 7. Sinclair, H. M. 1937. Growth factors for Phycomyces. Nature. 140: 361.
- 8. Schopfer, W. H. 1937. La spécificité d'action de l'aneurine sur *Phycomyces*. Le rôle des constituants de l'aneurine et de leurs produits de substitution. Bull. Soc. bot. Suisse 47: 460-464.
- 9. Schopfer, W. H. et Albert Jung. 1937. L'action des produits de desintegration de l'aneurine sur *Phycomyces*. Le second facteur de croissance des Mucorineés. Compt. Rend. Acad. Sci. Paris 204: 1500-1502.
- Schopfer, W. H. 1937. L'aneurine et ses constituants, facteurs de croissance de Mucorineés (*Parasitella*, *Absidia*) et de quelques espèces de *Rhodotorula*. Compt. Rend. Soc. biol. 126: 842.



Studies in the American Celastraceae I. New species of Microtropis, Wimmeria and Zinowiewia¹

C. L. LUNDELL (WITH THREE FIGURES)

In studies of the Mexican and Central American flora, particularly that of the Maya area, the need for a systematic study of the Celastraceae has interested the writer. Through a preliminary series of revisions of the genera of American Celastraceae, it is hoped that interest of collectors will be stimulated so that material of many of the lesser known genera and species can be accumulated to make possible later an adequate monographic treatment of the family. As illustrated by the situation in the genus Zinowiewia, many of the celastraceous species are poorly represented in herbaria, all too many being known from a single collection. That many interesting forms remain to be discovered is evident; no less than four of the new species of Zinowiewia were collected for the first time between 1933 and 1937.

Included in this paper are nine new species which represent undescribed forms discovered in revising the American species of *Microtropis*, and the genera *Wimmeria* and *Zinowiewia*.

In the list of citations of herbarium specimens, the following abbreviations of the names of herbaria are employed:

A-Arnold Arboretum, Jamaica Plain, Mass.

D—Dudley Herbarium, Stanford University, Calif.

F-Field Museum of Natural History, Chicago, Ill.

G-Gray Herbarium, Harvard University, Cambridge, Mass.

K-Royal Botanic Gardens, Kew, Surrey, England

M-University of Michigan, Ann Arbor, Mich.

Mo-Missouri Botanical Garden, St. Louis, Mo.

NY-New York Botanical Garden, New York, N. Y.

P—Academy of Natural Sciences, Philadelphia, Pa.

US-United States National Herbarium, Washington, D. C.

The writer is deeply indebted to the directors and curators of these institutions for their courtesy in making the material available. All of the cited specimens have been uniformly annotated with printed labels.

Microtropis Standleyi sp. nov.—Frutex epiphyticus, 2-metralis. Folia 5-8 mm. longe petiolata, chartacea, discolora, lanceolato-elliptica vel oblongo-elliptica, 5.5-9.5 cm. longa, 1.8-3.8 cm. lata, apice breviter acuminata, acumine obtusiusculo, basi cuneata vel acutiuscula. Cymae 2.3 cm. longae vel minores. Flores masculi virides. Sepala inaequalia, suborbicularia vel late

¹ Papers from the Herbarium of the University of Michigan.

ovato-orbicularia, 2 exteriora 1.2-1.4 mm. lata, interiora 1.5-2.2 mm. lata, margine minute erosa. Petala late obovata vel suborbicularia, 2-2.4 mm. longa, margine minute erosa. Discus pentagonus, crassus, ca. 1.8 mm. diam. Filamenta ca. 1 mm. longa. Antherae late cordatae, ca. 0.5 mm. longae. Ovarium in discum subimmersum. Flores femineos non vidi. Fructus ignotus.

An epiphytic shrub about 2 m. high, not scandent; branchlets usually opposite, rather slender, striate, drying reddish-black. Leaves chartaceous, paler beneath, margin entire, slightly revolute. Petioles canaliculate, 5 to 8 mm. long. Leaf blades lanceolate-elliptic or oblong-elliptic, 5.5 to 9.5 cm. long. 1.8 to 3.8 cm. wide, apex short acuminate, the acumen obtusish, base cuneate or acutish, costa prominent beneath, prominulous above, main lateral veins 4 or 5 on each side, strongly ascending from base, arcuately ascending from medial region, prominulous beneath, fainter above, veinlets inconspicuous. Cymes 2.3 cm. long or less, divaricately forked 3 to 5 times, each node bibracteate; peduncles stout, 3.5 to 7.5 mm. long; primary branches 2 to 4 mm. long; ultimate branches shorter. Bracts and bractlets semicymbiform, 1 to 1.5 mm. long, margin minutely erose, reddish. Staminate flowers green or pale green, pentamerous or tetramerous (excepting ovary), subsessile or with a very short thick pedicel. Sepals strongly unequal, suborbicular or broadly ovate-orbicular, the 2 outer 1.2 to 1.4 mm. wide, the inner 1.5 to 2.2 mm. wide, margin obscurely and minutely erose, reddish. Petals broadly obovate or suborbicular, 2 to 2.4 mm. long, margin very minutely erose. Disk usually pentagonous, rather thick, about 1.8 mm. wide, subcupular. Filaments inserted on angles of disk, about 1 mm. long; anthers broadly cordate, about 0.5 mm. long, short apiculate. Rudimentary ovary almost entirely submerged in disk, contracted above into a short style, incompletely 2-celled, with 4 collateral ovules on a short central placenta. Pistillate flowers and fruits unknown.

Type in the Herbarium of the Field Museum of Natural History (No. 599,103), P. C. Standley and Juvenal Valerio 50602, collected on Cerros de Zurquí, northeast of San Isidro, Province of Heredia, COSTA RICA, alt. 2000–2400 m., Mar. 3, 1926.

Additional specimens examined: COSTA RICA: Province of Heredia, Cerros de Zurquí, northeast of San Isidro, alt. 2000–2400 m., Mar. 3, 1926, Standley and Valerio 50602, staminate flowers, type collection (US); Standley and Valerio 50480, staminate flowers (F, US). Province of San José, Zurquí, alt. 2000–2500 m.; shrub in wet forest; Feb. 13, 1926, Standley and Valerio 48169, staminate flowers (US).

M. Standleyi is related to M. Schiedeana Loes. of Vera Cruz, but may be readily distinguished by its chartaceous leaves with main lateral veins 4 or 5 on each side, these strongly ascending from base at an acute angle, arcuately ascending from medial region. In M. Schiedeana the leaves are

subcoriaceous with main lateral veins 7 to 9 on each side, these patent, nearly horizontal.

Wimmeria acapulcensis sp. nov. (fig. 1).—Frutex. Folia 5–15 mm. longe petiolata, subcoriacea, remote et inconspicue serrulata, lanceolata vel ovata, 4.5–7 cm. longa, 2–3.8 cm. lata, apice obtusa vel rotundata, basi attenuata, acuminata, costa ad apicem utrinque debili, venis supra albidis, inconspicuis, subtus leviter impressis, obscuris. Cymae minute puberulae, longe pedunculatae. Pedicelli 5–6 mm. longi, ad basin puberuli. Calycis lobi inaequales, 1.4–2.5 mm. lati. Petala 5, minute pulverulento-puberula, suborbicularia, ca. 3 mm. longa secus medietatem, marginibus ca. 0.8 mm. ultra apicem productis. Filamenta ca. 2.3 mm. longa. Ovarium 3- raro 2-loculare, stylo crasso, ca. 0.8 mm. longo. Fructus depresso-orbiculares, 13–18 mm. longi, 18–22.5 mm. lati.

"A spreading shrub 24 dm. high" (Rose); branchlets pale, rather stout, compressed and strongly striate, puberulent around the nodes, glabrous otherwise. Leaves subcoriaceous, brittle, slightly paler beneath, borne mainly on short spur-like branches. Stipules minute. Petioles 5 to 15 mm. long, slender, shallowly canaliculate, puberulent above, the medial ridge conspicuous. Leaf blades lanceolate or ovate, 4.5 to 7 cm. long, 2 to 3.8 cm. wide, apex bluntly obtuse to rounded, base attenuate, acuminate, decurrent, costa prominent at base beneath, less conspicuous above, becoming faint near the apex, veins nearly plane above, whitened, impressed and almost obsolete beneath, margin remotely and inconspicuously serrulate with minute appressed nigrescent teeth. Cymes puberulent, long pedunculate, forked 1 to 3 times, the ultimate branches shortened, crowding the flowers. Bracts and bractlets minute, with toothed margins, the teeth red. Pedicels slender, puberulent only at base, 5 to 6 mm. long, jointed at base. Calyx 5-lobed, the lobes unequal, broadly rounded, 1.4 to 2.5 mm. wide, minutely apiculate, very minutely erose-ciliolate. Petals 5, minutely pulverulent-puberulent outside, 7- or 8-veined, suborbicular, 3 mm. long medially, with the overlapped margin prolonged laterally at apex as much as 0.8 mm., about 3.2 mm. wide, rufouspunctate, free margin very minutely ciliolate, overlapped margin erose. Stamens 5; filaments filiform-subulate, about 2.3 mm. long, inserted on lower edge of disk; anthers 1 mm. long. Disk thick, nearly flat, confluent with base of ovary, slightly rugose, minutely papillate. Ovary 3-winged, rarely 2-winged, 3-celled, rarely 2-celled, base submerged in disk. Style thick, terete, about 0.8 mm. long. Stigma subcapitate, trifid, rarely bifid. Fruits 3-winged, rarely 2-winged, usually broadest at the middle, depressed-orbicular, much wider than long, 13 to 18 mm. long, 18 to 22.5 mm. wide, crowned by the persistent stigma and style, deeply notched at apex and base, the wings membranous, with close veins; 1-seeded.

Type in the Herbarium of Arnold Arboretum, Edward Palmer 124, collected near Acapulco, Guerrero, Mexico, Nov. 1894.



Fig. 1. Wimmeria acapulcensis Lundell. Type collection (Palmer 124), in Missouri Botanical Garden Herbarium. $\times \frac{3}{4}$

Additional specimens examined: MEXICO: Guerrero, Acapulco and vicinity, Nov. 1894, *Palmer 124*, type collection (G, Mo, US).

Palmer 124 was described by Rose who made the untenable proposal to transfer the name W. pallida Radlk. to this species. (Contr. U. S. Nat. Herb. 5: 130. 1897.) Hartweg 41 (fig. 2) is the type collection of W. confusa Hemsl., and W. pallida Radlk. (as to flowers). W. confusa has priority, hence W. pallida is clearly a synonym.

W. acapulcensis is very distinct from W. confusa (compare figs. 1 and 2), differing markedly in its much larger bluntly obtuse or rounded leaves and larger fruits. It is also related to W. lanceolata Rose and W. persicifolia Radlk. but may be readily distinguished as both of these have long attenuate-acuminate leaves.

Wimmeria Bartlettii sp. nov.—Arbor glabra, 27 m. alta, 60 cm. diam. Folia 7–12 mm. longe petiolata, coriacea, lanceolata, lanceolato-oblonga vel elliptica, 6–13.5 cm. longa, 1.8–5.5 cm. lata, utrinque acuminata, serrulata. Cymae 1.3–3.5 cm. longae, pedunculatae. Pedicelli 3–13 mm. longi. Calyx profunde quinquefidus. Petala 5, late ovata, ca. 3 mm. longa in medietatem, marginibus lateralibus productis, fimbriatis, fimbriis saepe 1.3 mm. longis. Stamina 5. Filamenta 2.2–3 mm. longa. Antherae 1–1.2 mm. longae. Ovarium 3-raro 4-loculare. Fructus late ovati, suborbiculares vel oblongi, 3.5–5.2 cm. longi, 3–4 cm. lati.

A tree reaching a height of 27 m. and a diam. of 60 cm. (Bartlett, Lundell), with smooth gray bark; entirely glabrous; branchlets green, rather stout, striate. Leaves large, petiolate, coriaceous, slightly discolorous. Stipules minute, subulate, less than 1 mm. long. Petioles 7 to 12 mm. long, subcanaliculate above with a fine medial ridge. Leaf blades lanceolate, lanceolate-oblong, or elliptic, 6 to 13.5 cm. long, 1.8 to 5.5 cm. wide, acuminate at both ends, costa raised above as a narrow fine ridge extending nearly to apex, prominent beneath, main lateral veins 6 to 9 on each side, arcuately ascending, prominulous to obscure on both surfaces, veinlets usually inconspicuous and obscure, rarely slightly impressed, margin serrulate, the teeth subulate-tipped with appressed nigrescent teeth. Cymes 1.3 to 3.5 cm. long, pedunculate, forked 2 to 4 times. Bracts and bractlets broadly triangular, acutish, 0.35 to 0.8 mm. long. Flowers green (Bartlett). Pedicels slender, 3 to 13 mm. long, jointed at base. Calyx rather thick, 5-lobed, the lobes imbricate, broadly ovate-triangular, rounded or bluntly obtuse. Corolla contorted, very rarely imbricate; petals 5, broadly ovate, about 3 mm. long medially, the overlapped margin prolonged laterally at apex, thin, conspicuously fringed, the fimbriae as much as 1.3 mm. long. Stamens 5; filaments filiform-subulate, 2.2 to 3 mm. long, inserted at edge of disk; anthers 1 to 1.2 mm. long. Disk large, rather flat, thick, rugose, shallowly 5-lobed, confluent with base of ovary, distinctly glandular-punctate. Ovary usually 3-angled, 3- rarely 4-celled, base submerged in disk. Style very short, usually triquetrous. Stigma trifid. Fruits crimson



Fig. 2. Wimmeria confusa Hemsl. Type collection (Hartweg 41 from Zacatecas), in Kew Herbarium. $\times \frac{3}{4}$.

(Bartlett) or reddish-brown (Schipp), 3- rarely 4-winged, broadly ovate, broadly elliptic, or oblong in outline, 3.5 to 5.2 cm. long, 3 to 4 cm. wide at maturity, deeply cordate at base, shallowly emarginate to deeply notched at apex, crowned by the persistent stigma and style, the wings broad, membranous, with numerous fine close veins; 1- or 2-seeded, the seed erect, straight, linear, subterete, up to 1.8 cm. long, the testa finely verrucose, dark red; endosperm abundant; cotyledons flat, equal, linear-lanceolate, about 14 mm. long, apex obtuse; radicle up to 1.8 mm. long, subterete.

Type in the Herbarium of the University of Michigan, H. H. Bartlett 12435 (flowers), 12773 (fruits), collected in sapodilla and mahogany forest at Uaxactun, Department of Petén, Guatemala, April 2nd and 27th, 1931.

Additional specimens examined: GUATEMALA: Department of Petén, Uaxactun, in sapodilla and mahogany forest, March 21, 1931, Bartlett 12216, sterile (A, M); April 2, 1931, Bartlett 12435, type collection of flowers (A, Mo, NY, US); April 6, 1931, Bartlett 12481, flowers and fruits (A, D, M, NY, US); April 8, 1931, Bartlett 12536, flowers (A, M); April 27, 1931, Bartlett 12773, type collection of fruits (NY). La Libertad, Monte Chicbul, in forest on slope of limestone hill, C. L. Lundell 2640, sterile (M). Department of Izabal, lower Rio Dulce, March 2, 1885, Sereno Watson 43, fruits (G, K). BRITISH HONDURAS: El Cayo District, Valentin, in advanced, valley forest on limestone, June 27, 1936, Lundell 6278, flower buds (M-2). Toledo District, Temash River, on river bank in shade, April 22, 1934, W. A. Schipp 1296, fruits (A, F, G, M, Mo, NY).

Vernacular names: "Quiebra hacha blanco" (Bartlett 12216); "Chintoc" (Bartlett 12435); "Ixolte ixnuc" (Bartlett 12481).

Economic value: The wood is utilized locally for xylophone keys (Bartlett).

W. Bartlettii may be readily separated from the closely related W. concolor Schl. & Cham. by its much larger fruits as well as the fringed overlapped margin of the petals, the petals of W. concolor being merely erose on the overlapped margin.

Zinowiewia australis sp. nov.—Arbor 20 m. alta. Folia 6–8 mm. longe petiolata, subchartacea, ovato-elliptica, lanceolata vel elliptica, 5–8 cm. longa, 2.3–3.7 cm. lata, apice acuminata, acumine acutiusculo, basi abrupte attenuata, acuta. Fructus late oblanceolati vel obovati, 2–2.4 cm. longi, 7.5–9.5 mm. lati, apice rotundati, apiculati, valide venosi. Semen 1; cotyledonibus lanceolatis, 6.8–7.5 mm. longis, 2–2.1 mm. latis, apice rotundatis; radicula 3 mm. longa.

A tree about 20 m. high; branchlets slender. Leaves subchartaceous, dark green. Petioles slender, deeply canaliculate, 6 to 8 mm. long. Leaf blades

ovate-elliptic, lanceolate, or elliptic, 5 to 8 cm. long, 2.3 to 3.7 cm. wide, apex acuminate, the acumen acutish, base abruptly narrowed, acute, decurrent, costa slightly elevated above at base, prominent beneath, reticulateveined, the main lateral veins 4 to 6, margin revolute. Cymes subsessile, forked 4 or 5 times, the primary branches much shortened. Fruits broadly oblanceolate to obovate, 2 to 2.4 cm. long. 7.5 to 9.5 mm. wide, strongly veined, the veins nearly horizontal above the middle, veinlets well-developed from margin of wing, apex rounded, apiculate; 1-seeded, the seed 9 to 11 mm. long, 2.5 to 3 mm. in diam., subterete, nearly straight, the ends narrowed, rounded; cotyledons lanceolate, 6.8 to 7.5 mm. long, 2 to 2.1 mm. wide, rounded at apex; radicle linear, quadrangulate, 3 mm. long.

Type in the Herbarium of the Field Museum of Natural History (No. 894,843), *H. Pittier 13826*, collected in "Selvas nubladas, Agua y El Junquito," Venezuela, December 29, 1936, at alt. of 1800 m.

Vernacular name: "Canalete" (Pittier).

Z. australis is noteworthy for its dark green thin leaves, large obovate strongly veined samaras 20 to 24 mm. long and 7.5 to 9.5 mm. wide, and cotyledons 2 to 2.1 mm. wide.

Zinowiewia concinna sp. nov.—Arbor. Folia 4–8 mm. longe petiolata, subcoriacea, ovata, elliptico-oblonga vel lanceolata, 5.5–11 cm. longa, 2.5–4.5 cm. lata, apice abrupte acuminata, basi acuta. Cymae 1.3–2.5 cm. longae. Calyx profunde quinquefidus, lobis ca. 0.5 mm. longis, rotundatis. Petala 5, late ovata vel ovato-oblonga, 1.5–1.7 mm. longa, 1–1.2 mm. lata. Filamenta ca. 0.6 mm. longa. Antherae ca. 0.4 mm. longae. Ovarium in discum immersum. Fructus oblanceolati, 2–2.2 cm. longi, 6.5–7 mm. lati, acutiusculi, apiculati, venis debilibus. Semen 1; cotyledonibus lineari-lanceolatis, ca. 5.5 mm. longis, obtusis; radicula ca. 2.7 mm. longa.

A small tree (Pringle) or large tree (Hinton). Leaves subcoriaceous or subchartaceous. Petioles 4 to 8 mm. long, canaliculate. Leaf blades ovate, elliptic-oblong, or lanceolate, 5.5 to 11 cm. long, 2.5 to 4.5 cm. wide, apex acuminate, the acumen obtusish or acute, base acute, decurrent, costa nearly plane above or slightly impressed, prominent beneath, openly reticulateveined, the main lateral veins 6 to 8 on each side. Cymes subsessile or short pedunculate, 1.3 to 2.8 cm. long, forked 4 to 6 times, the primary branches usually much shortened, crowded. Pedicels 2 to 3.5 mm. long, slender, jointed at or near the middle. Calyx 5-lobed, the lobes about 0.5 mm. long, the margins bearing slender red deciduous teeth. Petals 5, broadly ovate or ovate-oblong, 1.3 to 1.7 mm. long, 1 to 1.2 mm. wide, apex rounded. Filaments about 0.6 mm. long. Anthers about 0.4 mm. long. Disk pentagonal. Ovary submerged in disk; ovules small, about 0.25 mm. long. Fruits subfalcate, oblong-elliptic, 2 to 2.2 cm. long, 6.5 to 8 mm. wide, acutish or obtusish, apiculate, venation faint; seed linear-oblong, 8 to 10 mm. long; cotyledons linear-lanceolate, about 5.5 mm. long, obtuse; radicle about 2.7 mm. long, slender.

Type in the Herbarium of the University of Michigan, C. G. Pringle 8438, collected on Sierra de Tepoxtlan, near Cuernavaca, Morelos, Mexico, September 11, 1900, at alt. of 2450 m.

Additional specimens examined: MEXICO: Morelos, Sierra de Tepoxtlan, Feb. 8, 1899, Pringle 8024 (A, C, F, G, Mo, P, US-2); Sept. 11, 1900, Pringle 8438, type collection (A, C, F, G, Mo, NY, P, US-2); Nov. 20, 1902, Pringle 9706 (F, G, NY, Mo, US-2). Michoacan, Sta. Maria, Oct. 1909, Arsene (F). State of Mexico, District of Temascaltepec, Mina de Agua, alt. 1990 m., Oct. 31, 1932, G. B. Hinton 2332 (K, US); Feb. 4, 1933, Hinton 3253 (K).

Vernacular name: "Gloria" (Hinton).

Economic value: "Used in necessity for fodder" (Hinton).

The faintly-veined acutish wing of its oblong-elliptic samaras, the long pedicels, and the obtusish or acute acumen of the leaves distinguish Z. concinna from Z. integerrima (Turcz.) Turcz. to which it is very closely related. Z. integerrima has broadly oblanceolate or obovate rounded more strongly veined samaras, much larger cymes, shorter pedicels, and bluntly obtuse subacuminate leaves.

Zinowiewia costaricensis sp. nov.—Arbor. Folia 4–9 mm. longe petiolata, chartacea, parva, lanceolata, 3.5–8.5 cm. longa, 1.3–2.8 cm. lata, utrinque acuminata. Cymae ca. 1.5 cm. longae. Calyx profunde quinquefidus, lobis ca. 0.5 mm. longis, rotundatis. Petala 5, late ovata vel suborbicularia, 1.1–1.3 mm. longa, 1–1.1 mm. lata, apice rotundata, inconspicue erosa. Fructus oblanceolato-oblongi, 1.5–2.1 cm. longi, 5–6.5 mm. lati, apice emarginati. Semen 1 vel 2; cotyledonibus lineari-lanceolatis, 5.2 mm. longis, ca. 1.2 mm. latis, apice rotundatis; radicula 2.3 mm. longa.

A tree; branchlets slender. Leaves chartaceous, discolorous. Petioles slender, 4 to 9 mm. long, shallowly canaliculate. Leaf blades lanceolate, 3.5 to 8.5 cm. long, 1.3 to 2.8 cm. wide, apex and base acuminate, decurrent, much paler beneath, costa slightly raised above, prominent beneath, the main lateral veins 4 to 6 on each side. Cymes small, usually about 1.5 cm. long, forked 3 or 4 times. Calyx 5-lobed, the lobes rounded, about 0.5 mm. long. Petals 5, broadly ovate to suborbicular, 1.1 to 1.3 mm. long, 1 to 1.1 mm. wide, rounded at apex, inconspicuously erose. Margin of disk raised. Fruits oblanceolate, 1.5 to 2.1 cm. long, 5 to 6.5 mm. wide, subfalcate (1-seeded) or straight (2-seeded), venation of wing strongly ascending, faint, scarcely discernible near the margin, apex emarginate; 1-celled and 1-seeded, or 2-celled and 2-seeded, the seed erect, linear-oblong in outline, terete, 6 to 8 mm. long, apex rounded; cotyledons linear-lanceolate, rounded at apex, 5.2 mm. long, about 1.2 mm. wide; radicle 2.3 mm. long.

Type in the United States National Herbarium (No. 471,825), Tonduz

7861, collected on Cuesta de Terrazu, Costa Rica, at alt. of 1900 m. in April 1893.

Additional specimens examined: COSTA RICA, Cuesta de Terrazu, April 1893, *Tonduz 7861*, type collection (US-No. 577,182). Monte Candelaria, February 1847, *Oersted 116K* (F-fragment, US). PANAMA, vicinity of El Boquete, Chiriqui, alt. 1000 to 1300 m., March 2–8, 1911, W. R. Maxon 5109 (F-2).

Z. costaricensis is noteworthy for having emarginate fruits 1- or 2-seeded, all the other species in the genus being strictly 1-seeded so far as known. The relatively small, discolorous, lanceolate leaves, acuminate at apex and base, distinguish the species further. The Oersted and Tonduz collections, excepting No. 577,182 (US), are homogeneous. In the Tonduz specimen, No. 577,182, apparently taken from a different tree than the type specimen, the fruits appear abnormal, being smaller than usual and obtusish. The leaves, however, are typical.

The Panama specimens, referred tentatively to Z. costaricensis, have leaves ovate or ovate-lanceolate, cymes as much as 3 cm. long, and petals slightly larger (about 0.2 mm. longer and proportionately wider). Young fruits are typically emarginate, but slightly broader; all of those available are 1-seeded.

Zinowiewia Matudai sp. nov.—Arbor 7–9 m. alta, 15 cm. diam. Folia 7–11 mm. longe petiolata, chartacea vel subcoriacea, anguste oblonga, oblongo-elliptica, vel oblanceolata, 5–9 cm. longa, 2–3.5 cm. lata, apice acuminata, acumine obtusiusculo vel acuto, basi subacuminata. Cymae 1.4–2.4 cm. longae. Flores purpurei. Calyx profunde quinquefidus, lobis late ovatis, ca. 0.5 mm. longis, obtusiusculis vel rotundatis. Petala 5, ovata, 1.6–2 mm. longa, 1–1.2 mm. lata, obtusiuscula vel rotundata. Filamenta ca. 0.7 mm. longa. Antherae ca. 0.25 mm. longae. Ovarium in discum subimmersum. Fructus oblongi, 12–15 mm. longi, 4–5 mm. lati, apice obtusi, apiculati, venis debilibus. Semen 1, cotyledonibus lineari-lanceolatis, ca. 3 mm. longis, obtusis; radicula 1.2–1.4 mm. longa.

A tree 7 to 9 m. high, 15 cm. in diam.; branchlets slender, drying reddish-black, striate, slightly compressed at nodes. Leaves chartaceous at first, subcoriaceous with age, drying yellow-green, somewhat paler beneath. Petioles slender, 7 to 11 mm. long, canaliculate, reddish. Leaf blades narrowly oblong, oblong-elliptic, or oblanceolate, 5 to 9 cm. long, 2 to 3.5 cm. wide, apex acuminate, the acumen obtusish or acute, base subacuminate, distinctly callosed and revolute on each side, costa prominent beneath, slightly impressed above, openly reticulate-veined beneath, main lateral veins 6 to 8 on each side, prominulous beneath, inconspicuous above, arcuately ascending, anastamosing into a submarginal vein. Cymes 1.4 to 2.4 cm. long, pedunculate, forked 3 to 5 times, the branches short, crowding the flowers.

Flowers purplish (Matuda). Pedicels very short, usually less than 0.5 mm. long, jointed at or near the middle. Calyx 5-lobed, the lobes broadly ovate, about 0.5 mm. long, obtusish or rounded. Petals 5, ovate, 1.6 to 2 mm. long, 1 to 1.2 mm. wide, obtusish or rounded. Filaments subulate, about 0.7 mm. long. Anthers about 0.25 mm. long. Disk thick, pentagonal. Ovary almost entirely submerged in disk. Style slender, equaling filaments in length. Samaras oblong-elliptic, 12 to 15 mm. long, 4 to 5 mm. wide, subfalcate, the wing decurrent to base on side opposite seed, lateral veins above middle of wing nearly horizontal, faint, veinlets undeveloped from margins, apex obtuse or bluntly obtuse, apiculate; 1-celled, 1-seeded, the seed erect, lanceolate-oblong in outline, 4.5 to 5 mm. long, nearly terete, reddish; cotyledons linear-lanceolate, about 3 mm. long, obtuse; radicle 1.2 to 1.4 mm. long.

Type in the Herbarium of the University of Michigan, *Eizi Matuda* 1872, flowers and fruits, collected at Buena Vista, Escuintla, Chiapas, Mexico, January 1938.

Additional specimens examined: MEXICO: Chiapas, Mt. Ovando near Escuintla, Dec. 17, 1936, Matuda 424, flowers and fruits.

The callosed revolute base of the leaf blades, evident in the youngest unfolded leaves, is a peculiarity of this species. The yellow-green hue of the leaves, the purplish subsessile flowers, and the small fruits and seeds distinguish it further. Its closest relative is Z. rubra Lundell of Guatemala.

Zinowiewia pallida sp. nov. (fig. 3).—Arbor glabra, 10 m. alta, 10 cm. diam. Folia 3–5 mm. longe petiolata, pallida, subcoriacea, oblanceolata, raro oblanceolato-elliptica, 4–9.5 cm. longa, 1.4–3.3 cm. lata, apice obtusa, raro rotundata, minute apiculata, basi acuminata. Flores parvi, pallide virides. Calyx profunde quinquefidus, lobis ca. 0.4 mm. longis, rotundatis. Petala 5, late ovata, 1.2–1.3 mm. longa, ca. 1 mm. lata. Stamina 5; filamentis ca. 0.5 mm. longis; antheris late cordatis, ca. 0.3 mm. longis. Ovarium in discum immersum. Fructus immaturus samaroideus.

A tree 10 m. high and 10 cm. in diameter, with short trunk; branchlets slender, red at first, whitened in age. Leaves pallid, subcoriaceous. Petioles reddish, 3 to 5 mm. long, slightly canaliculate. Leaf blades oblanceolate, rarely oblanceolate-elliptic, 4 to 9.5 cm. long, 1.4 to 3.3 cm. wide, apex obtuse or rarely rounded, minutely apiculate, base acuminate, slightly decurrent, discolorous, the young leaves whitish beneath, costa elevated above on lower half of blade, pinkish and very prominent beneath the entire length, main lateral veins 5 to 8 on each side, inconspicuous above, prominulous beneath, anastamosing near the margin. Cymes 2 to 2.8 cm. long, pedunculate, forked 4 or 5 times, open. Flowers small, pale green. Pedicel of terminal flower in cymules 1.2 mm. long, jointed at base; pedicels of lateral flowers in ultimate cymules about 2 mm. long, jointed at middle. Calyx 5-lobed, the lobes about 0.4 mm. long, rounded. Petals 5, broadly ovate, 1.2 to 1.3 mm. long, about 1

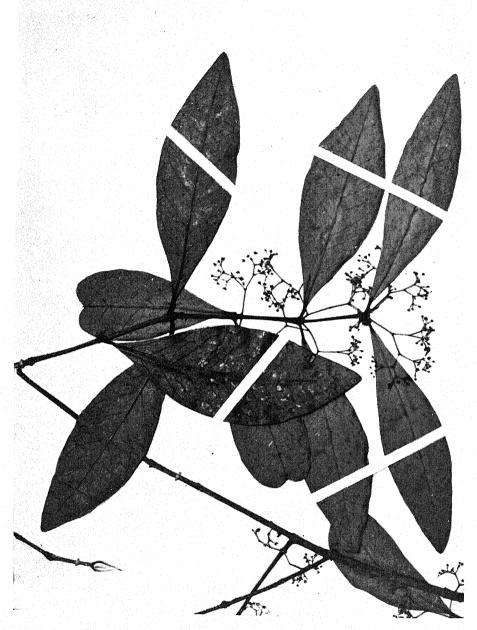


Fig. 3. Zinowiewia pallida Lundell. Type specimen (Lundell 6794), in Herbarium of the University of Michigan. $\times \frac{3}{4}$.

mm. wide. Filaments about 0.5 mm. long. Anthers about 0.3 mm. long. Disk thick, pentagonal, margin nearly plane. Ovary submerged in disk. Young immature fruits samaroid, typical of genus.

Type in the Herbarium of the University of Michigan, C. L. Lundell 6794, collected in open granite bed of Rio On, Mountain Pine Ridge, El Cayo District, British Honduras, Aug. 5, 1936.

In its obtuse rather than subacuminate or acuminate leaves, Z. pallida differs from all other species in the genus. It is evidently related to Z. integerrima (Turcz.) Turcz.

Zinowiewia rubra sp. nov.—Arbor 30 m. alta, 75–90 cm. diam. Folia 3.5–11 mm. longe petiolata, subchartacea vel subcoriacea, lanceolata vel lanceolato-elliptica, 4–11 cm. longa, 1.5–3.5 cm. lata, acuminata vel subacuminata, acumine acuto vel obtusiusculo, basi acuminata vel acuta. Cymae 2 cm. longae vel breviores. Flores rubri. Calyx profunde quinquefidus, lobis late triangulari-ovatis, ca. 0.5 mm. longis, obtusis. Petala 5, ovata, 2–2.2 mm. longa, ca. 1.5 mm. lata, apice rotundata. Filamenta ca. 0.75 mm. longa. Antherae minutae, ca. 0.2 mm. longae. Ovarium in discum immersum. Semen 1.

A large tree; branchlets dark red, rather stout, internodes short or elongated. Leaves subchartaceous or subcoriaceous. Petioles 3.5 to 11 mm. long, reddish. Leaf blades lanceolate or lanceolate-elliptic, 4 to 11 cm. long, 1.5 to 3.5 cm. wide, apex usually acuminate, sometimes subacuminate, the acumen acute or obtusish, base acuminate or acute, decurrent, costa narrow above, pinkish and prominent beneath, openly reticulate-veined, the main lateral veins 5 to 8 on each side. Cymes 2 cm. long or less, short pedunculate or subsessile, the peduncles and branches stout, forked 2 to 4 times. Flowers crowded, maroon or tinged maroon. Pedicel of terminal flower in cymules about 1.2 mm. long, jointed at or above the middle; pedicels of all lateral flowers jointed above the middle. Calyx 5-lobed, the lobes broadly triangular-ovate, about 0.5 mm. long, obtuse. Petals 5, ovate, 2 to 2.2 mm. long, about 1.5 mm. wide, apex rounded. Filaments subulate, about 0.75 mm. long. Anthers minute, about 0.2 mm. long. Disk green, pentagonal. Ovary submerged in disk. Immature fruits oblong-elliptic, dull red (Skutch 1680), 1-seeded, obtusish.

Type in the Herbarium of the University of Michigan, A. F. Skutch 639, a tree 75 cm. in diam., flowers maroon with a green disk, in clearing above Tecpam, Department of Chimaltenango, Guatemala, alt. 2800 m., Oct. 14, 1933.

Additional specimens examined: GUATEMALA: Department of Chimaltenango, Tecpam, Skutch 639, type collection (D, NY, US). Department of Quiché, Nebaj, a tree to 30 m. high and 90 cm. in diam., flowers green tinged with maroon, fruits dull red, in remnant of cloud

forest, alt. 2550 m., Nov. 16, 1934, Skutch 1680, flowers and young fruits (F).

Z. rubra, the largest tree in the genus, may be easily recognized by its comparatively large maroon or maroon tinged petals as much as 2.2 mm. long and 1.5 mm. wide. It is closely related to Z. Matudai, but differs in its longer pedicels, larger flowers, green rather than yellow-green leaves, and the absence of the callosed revolute base of the leaf blades.

University of Michigan Ann Arbor, Michigan

The emergence of smut-inoculated oat seedlings through sand and loam soil¹

PAUL F. BRANDWEIN (WITH ONE FIGURE)

In experiments on the nature of smut infection in various oat varieties, the writer has observed the emergence through sand of seedlings inoculated with the loose smut, Ustilago avenae (Pers.) Jens., and the covered smut, U. levis (Kell. and Sw.) Magn. In experiments involving the use of approximately 10,000 seeds, half of which were uninoculated controls, there was 98.7 per cent emergence of plants from uninoculated seeds as compared with 97.2 per cent emergence of plants from seed inoculated with different races of smuts maintained at the Brooklyn Botanic Garden. However, Bayles and Coffman (1) have shown that dehulling reduced the emergence through soil of plants grown from uninoculated seed by 5.8 per cent and of inoculated seed by 10.6 per cent. Stevens (2) in field experiments reported that the smut-resistant Markton oat is injured by inoculation that results in the killing of many seeds and thus reduces the stand. After the seedlings emerge, however, there appeared to be no detrimental results. These observations pointed to the desirability of conducting experiments to discover some reason for these differences in emergence of seedlings through soil and sand.

The technique generally employed in this laboratory was used with the exception that seeds were planted in soil as well as in sand for purposes of comparison. The soil used was a good loam soil, screened through a 40 mesh sieve. The sand was similarly sieved through the same mesh.

In these experiments 110 cc. of soil or sand was placed in a waxed paper cup. The cup was then tapped several times on the table and ten seeds were placed at approximately equidistant points on this sand or soil base, and covered with an equivalent quantity.

Both sand and soil had a moisture content of 20 per cent of their water holding capacity and the cups were maintained at a constant temperature of 20°C. The ten seeds had been placed in coin envelopes and inoculated with about 10 milligrams of smut spores, the excess being spread as evenly as possible when planted. The dehulled seeds of the varieties Monarch and Markton were inoculated with the Missouri race of *Ustilago levis*, to which Monarch is very susceptible and to which Markton is highly resistant.

Four different plantings were made: soil only, sand only, soil base with sand cover and sand base with soil cover. All four sets were planted

¹ Brooklyn Botanic Garden Contribution No. 86.

simultaneously, 100 seeds being used in each set. The emergence of seed-lings was recorded as follows:

	Per cent emergence		
	Inoculated	Uninoculated	
Markton—Soil only	98	99	
Sand only	100	100	
Soil base, sand cover	99	98	
Soil cover, sand base	100	100	
Monarch—Soil only	98	98	
Sand only	99	98	
Soil base, sand cover	100	99	
Soil cover, sand base	98	99	

From the results, it seems clear that under these conditions, the emergence of the seedlings might be considered unaffected by soil, the slight difference in Markton being insignificant. However, these conditions do not simulate those present in the field. Plantings, therefore, were made in the field as described in a previous paper (3) with the exception that the seeds were immediately planted three inches beneath the surface of the soil. The rows of dehulled inoculated seed alternated with those which were inoculated. Two hundred seeds were used in each planting.

	Per cent emergence			
Inoculated		Uninoculated		
Markton—Plantings of April 10	90	96		
Plantings of April 25	86	94		
Plantings of May 22	88	94		
Monarch—Plantings of April 10	80	88		
Plantings of April 25	84	96		
Plantings of May 22	80	92		

From the field experiments there seems to be a definite reduction of the emergence through soil of plants from inoculated seed. The emergence of seedlings of Markton was reduced by 6.7 per cent and of Monarch by 10.7 per cent. This apparently confirmed the results of Bayles & Coffman (1) and of Stevens (2).

While no attempt had been made to tamp the soil other than to pat it firmly in place, careful examination showed that within a day or so, in the field, the soil had become packed to a varying extent in different portions of the experimental plot. This pointed to tamping as one of the factors which must be considered in evaluating the percentages of emergence of seedlings. Preliminary experiments were therefore begun with the added procedure that the soil or sand was tamped to simulate the observed condition of the soil in the field.

In sand, with light tamping (i.e., merely tapping the sand in place with

a wooden tamper) under the conditions of constant moisture and temperature previously described, there was 100 per cent emergence of Monarch and Markton seedlings from uninoculated seed as well as from seed inoculated with *U. levis*. Where a loam soil was allowed to settle on the seeds by tapping the waxed paper cups in which the germination was carried on, there was 98 per cent emergence of seedlings from inoculated seeds of Markton and 99 per cent emergence of the uninoculated controls. The

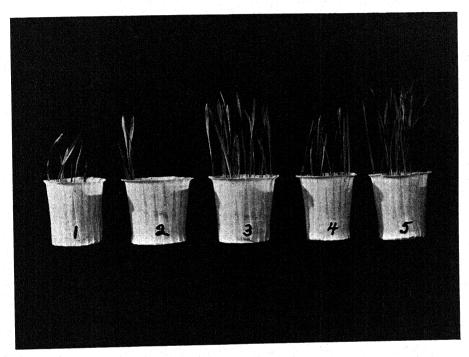


Fig. 1. Emergence of seedlings of Markton in heavily tamped soil and sand. (1, 2) inoculated with *Ustilago levis*, in heavily tamped loam soil; (3) the same, in heavily tamped sand; (4) uninoculated, in heavily tamped loam soil; (5) uninoculated, in heavily tamped sand.

Photograph taken 14 days after planting.

slightly lower emergence in soil as compared with sand may be accounted for by the various seedling-rot fungi which were present in the soil. However, when the loam soil was tamped as heavily as possible in the cups by pressing on the wooden tamper, so that the folds of the cup were slightly separated by the force used, there was a remarkable difference in the behavior of inoculated and uninoculated seeds. In such cases of heavy tamping, the emergence from inoculated seeds of the susceptible Monarch was reduced to an average of 55.5 per cent as compared with 82.5 per

cent emergence from the uninoculated controls. The emergence of plants of the resistant Markton variety was reduced to 75.3 per cent as compared with 90 per cent emergence from the uninoculated seed.

In sand, however, such heavy tamping had little effect in reducing emergence (fig. 1). In Markton, the emergence of inoculated seedlings through such heavily tamped sand (as described above for soil) was 98 per cent as compared with 98.5 per cent for the uninoculated. In Monarch, the emergence of the inoculated seedlings was 96 per cent as compared with 97 per cent for the uninoculated. In heavily tamped sand, the inoculated seedlings were in some cases slightly smaller on emergence as compared with the uninoculated; but after emergence grew to the same height as in the uninoculated (fig. 1). In soil, there was a marked difference in date of emergence; inoculated plants generally emerged one-half to a day later than the uninoculated controls.

In no case was the average emergence number of the inoculated seedlings higher than the uninoculated ones of any single cup in a given series of plantings. While this made these results significant, it was decided to attempt to control the tamping. Plantings were therefore made in vials 30 mm. X 100 mm. with one seed to the vial. All vials were carefully measured to insure equality of height, depth and width. Thirty grams of sand, previously prepared by screening through the 40 mesh sieve and by moistening to 20 per cent of the water holding capacity, was used as a base and an equivalent amount of sand used as a cover. Another vial which slid easily into the planting vial was weighted with enough mercury to make its total weight 300 gms. As soon as 30 grams of the moistened sand had been placed in the larger vial, the latter was gently tapped to permit the sand to settle. Then the weighted vial was dropped from a carefully measured height (within the larger vial) on the sand. This height was approximately 25 mm. from the top of the sand. Depending on the severity of the tamping desired, the vial could be dropped as many times as necessary. After the sand base was tamped, the inoculated seed was placed centrally and about 2 milligrams of smut spores were added in excess. At this time the 30 grams of sand was added as the cover. This was then tamped as before. The vials were stoppered with a plug of nonabsorbent cotton which was placed as near to the surface of the sand as possible. All the vials were placed in an incubator at 20°, the air being maintained approximately at saturation from two containers of water.

Since previous experiments had shown that sand could not be tamped as tightly as soil, it was decided to use a very heavy tamping in order to obtain measurable results. After several trials, it was decided to drop the 300 gram vial 20 times and to permit the growth of seedlings for 10 days

in this tightly packed sand. They were then removed for measurement and subjected to various other examinations dealing with the extent of smut infection. A control consisted in tamping the sand twice with the mercury weighted vial. The control seedlings were measured after three days, just before emergence.

The results obtained are summarized in table 1. It seems clear that there is a difference between the inoculated and non-inoculated plants under heavy tamping. Under light tamping in sand there is no difference

TABLE 1

Influence of tamping on the emergence of seedlings of Monarch and Markton oats inoculated with Ustilago levis, and non-inoculated controls.

VARIETY	PER CENT GERMINATION	A	VERAGE HEIGHT IN MM.	
Series A—tamped 20 times MONARCH				
Inoculated	75		16.3	
Non-inoculated Markton	95		25.0	
Inoculated Non-inoculated	85 100		20.1 25.3	
Series B—tamped twice	100		20.0	
Monarch				
Inoculated	100		10.3	
Non-inoculated	100		9.6	
MARKTON				
Inoculated	100		11.8	
Non-inoculated	100		12.8	

In each experiment 40 seeds were planted.

The seedlings in Series A were measured when 10 days old, and those in Series B when 3 days old, in both series before emergence.

between the two. The latter fact bears out countless observations carried out in the Laboratory of Plant Pathology of the Brookyn Botanic Garden.

It is suggested that the marked smaller size of the inoculated seedlings of both the susceptible variety Monarch and the resistant variety Markton is in some measure due to the coleoptile invasion which has been found (3, 4, 5) to be present in resistant as well as susceptible varieties. Undoubtedly, in Monarch, and in Markton to a much lesser extent, the further mycelial penetration of other plant tissues plays some part in retarding the emergence of the plant under pressure. In Monarch, the mycelial invasion of the other plant tissues by *U. levis* is rapid. In Markton, too, Smith and Bressman (6) have reported several cases of smut sporulation when that variety was inoculated with various races of the covered

smut. In addition, Western (5) has shown some infection of the coleoptile and mesocotyl of Markton when inoculated with the covered smut; he did not note any infection of the growing point. The present writer (3) has noted at least one infection of the growing point of Markton by $U.\ levis$, and since then has had occasion to note two other cases of infection as evidenced by the sporulation of the smut. However, it appears (3, 4, 5) that for the great majority of resistant plants, the mycelium does not go further than the coleoptile. From observations made by Western and by the writer, it seems further evident that the extent of infection of the coleoptile of susceptible plants is much greater than that of resistant plants. Indeed, in the latter the infection sometimes is found to consist of a few attenuated and disorganized hyphae. It seems clear, however, that in resistant plants, the extent of the invasion by the mycelium may vary considerably.

In emergence, it appears to be the coleoptile which shields the tissues as the plant pushes through the soil or sand. It may be that the coleoptile is weakened by the mycelial invasion so that it cannot penetrate as effectively as does the uninoculated plant through tamped loam soil which furnishes the resistance that loosely tamped or loosely adhering particles of soil or sand do not present. This tamping effect may help to furnish a partial explanation of the results of Bayles & Coffman (1) and Stevens (2). In any case, my results point to the advisability of taking this tamping effect into consideration where experiments designed to test the susceptibility or resistance of an oat variety are conducted. In this Laboratory, preliminary plantings are made in loosely tamped sand in paraffin cups under constant moisture and temperature. After emergence the seedlings are transplanted to the field. In this manner, any adverse effects of tamping, damping-off fungi, shifting temperature, undependable conditions of moisture, are obviated. Furthermore, maximum infections are obtainable when this technique is used.

Many thanks are due to Dr. G. M. Reed for the material and the advice he has so unfailingly and generously given.

SUMMARY

Under severe tamping, the emergence of smut-inoculated seedlings of both susceptible and resistant oat varieties is reduced as compared with their uninoculated controls.

It is suggested that the coleoptile infection found by Kolk, Western and the present writer, to be present in inoculated resistant and susceptible oat varieties may be responsible for the failure of these plants to penetrate such tightly packed soil.

Examination of seedlings under heavy pressure shows a smaller size and lower germination of the inoculated plants as compared with their non-inoculated controls. Both Monarch, a susceptible variety, and Markton, a resistant form, showed similar reactions.

WASHINGTON SQUARE COLLEGE

NEW YORK UNIVERSITY

BROOKLYN BOTANIC GARDEN

Literature cited

- 1. Bayles, B. B. and F. A. Coffman, 1929. Effects of dehulling seed and of date of seeding on germination and smut infection in oats. Jour. Amer. Soc. Agron. 21: 41-51, illus.
- 2. Stevens, H. 1936. The effect of latent infection on the smut-resistant Markton oat. Jour. Amer. Soc. Agron. 28: 711-713.
- 3. Brandwein, P. F. 1937. Experiments on latent infection of resistant varieties by the loose and covered smut of oats. Bull. Torrey Club 64: 433-444.
- 4. Kolk, M. 1930. Relation of host and pathogen in the oat smut, *Ustilago Avenae*. Bull. Torrey Club 57: 443-507, illus.
- 5. Western, J. H. 1936. The Biology of Oat Smuts. IV. The invasion of some susceptible and resistant oat varieties, including Markton, by selected biological species of smut, *Ustilago Avenae* (Pers.) Jens. and *Ustilago Kolleri* Wille. Annals of Applied Biology 23: 245-263.
- 6. Smith, C. and E. N. Bressman. 1931. Susceptibility of Markton and other varieties of oats to covered smut, *Ustilago levis*, Jour. Amer. Soc. Agron. 23: 465-468.



Salt spray: An important factor in coastal ecology*

B. W. Wells and I. V. Shunk (WITH THREE FIGURES)

INTRODUCTION

Everyone who has visited sea coasts has noted the marked modification of form of woody plants close to the ocean; these are greatly repressed on the seaward side having a characteristic sloping form which has been universally called "wind form." The axes of the repressed shrub masses and of the one-sided trees are always in the direction of the strongest winds from the sea, which along most of the eastern U. S. coast are northeast (figs. 1 and 2).

The term "wind form" has not only had the descriptive connotation but the causal one as well. In Plant Sociology of Braun-Blanquet and Fuller (1932) is a statement and an illustration pointing to coastal winds as the cause of "wind form." Weaver and Clements in their Plant Ecology (1938) state, "On wind swept coasts and on high mountains excessive water loss results in a stunted and gnarled growth. This is, however, partly due to the mechanical effect of the wind." These books reflect the apparently obvious conception held by all observers to date, that wind is the factor involved.

The only report we have been able to find indicating injury by salt spray is that of Boodle, who reaches the conclusion, "that the scorching of foliage by sea winds is chiefly due to the drying action of the wind but the salt may perhaps occasionally contribute toward the production of an injurious effect."

It is the purpose of this paper on the basis of observations made during the spring of 1937, to show that the "wind form" is not due to wind *per se* but to the salt spray carried by the wind, killing the growing shoots. This study brings to the front a factor almost unrecognized, yet of the greatest importance in coastal plant ecology.

THE EVIDENCE

On the North Carolina coast, with the exception of the low sea-elder shrub (*Iva imbricata*), no woody plants occur on the dunes next to the strand. Here the sea oats (*Uniola paniculata*) is strongly dominant accom-

^{*} Research contribution No. 3 published with the aid of the State College Research Fund. Department of Botany, North Carolina State College of Agriculture and Engineering of the University of North Carolina.

¹ Boodle, L. A. The scorching of foliage by sea winds. Jour. Ministry Agri. Great Britain 27: 479-486. 1920.

panied by a few other herbs highly distinctive of this most exposed sea front zone. The woody plants occur on flats or low sandhills behind the sea front dunes.

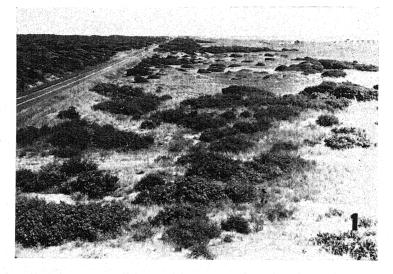


Fig. 1. Spray forms (formerly called "wind forms") Myrica cerifera and Ilex vomitoria near Fort Fisher, 20 miles south of Wilmington, N. C. Spray repressed Pinus Taeda on left of road.

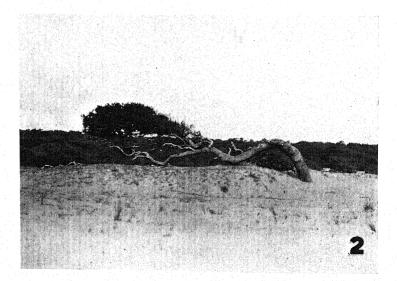


Fig. 2. Extreme spray form of *Quercus virginiana* near Nags Head, N. C., 55 miles north of Cape Hatteras.

Working on the seaward side of the Cape Fear peninsula below Wilmington, North Carolina, on April 16 we tagged a number of the new shoots of various "wind form" shrubs and trees found in this arboreal zone (fig. 1).

On April 30 we were surprised to find severe injury to the new shoots which occurred uniformly on the southeastern sides of the shrub masses. This definitely indicated some cause associated with a high southeast wind. The injury consisted of the killing of the upper younger tissues of the stems, the small immature leaves and the margins of the half developed leaves lower down, the necrotic areas of the latter appearing in a definite marginal pattern, extending proximally from the tip. It was noted that the most injured shoots were those most exposed. Those which were even slightly protected in shallow depressions in the compact shrub face, showed little or no injury. Upon checking the wind records at the Wilmington Weather Bureau Office (18 miles distant) we found a southeast wind of a relatively high intensity recorded for a period of 19 hours extending from the evening of April 24th to the afternoon of the 25th. This wind at the city station, 12 miles from the ocean, reached a maximum velocity of 28 miles per hour, the average, however, being 15.4 miles per hour. The seaside intensities would probably be much higher than these. No other wind approaching this one in duration or intensity occurred during the two-week interval. The sky during the high wind period was cloudy, and the soil water had been high in consequence of the frequent rains of the spring season. These two conditions eliminated the drying effect of the wind as a killing agent, forcing the conclusion that the injury must be ascribed to the salt spray carried in the wind.

Fortunately near the site of our original observations, nature arranged a perfect demonstration of this salt spray effect. Just south of the old Fort Fisher, relic of Civil War days, the peninsula suddenly narrows to little more than the width of the ocean strand and dune, due to the presence there of an estuary of the Cape Fear River. Stretched across the peninsula in front of this bay and facing directly to the southeast was a zone of the familiar coast shrubs dominated by the wax myrtle (Myrica cerifera) (fig. 3). A close examination of this shrub zone gave perfect confirmatory evidence that the further away from the sea a plant was located, the less noticeable was the injury. The first shrubs on which no injury was detectable were 280 yeards (.16 miles) from the sea, as measured on a direct line east from the ocean, and about $\frac{1}{2}$ mile from a point where a southeast wind could pick up the spray from the surf. Many of these uninjured shrubs were well isolated on the salt meadow fully exposed to east and southeast winds yet they showed not the slightest tendency to

a slope form in relation to the sea winds. Thus the southeast-facing shrub zone gave conclusive evidence of the role of the spray factor.

One observation still puzzled us. It was repeatedly noted on the repressed sea-front shrubs that, where the young and tender shoots were slightly depressed in the compact surface of the fastigiate twig mass, little or no injury occurred. So shoots of approximately equal surface area were taken from exposed and slightly depressed positions and carefully washed with equal amounts of distilled water. A few drops of silver nitrate solution were added to each of the washings. That from the exposed shoot gave a strong chloride precipitate, while that from the depressed shoot gave barely a trace. Why shoots so slightly depressed should escape from the spray, was puzzling until it was realized that a strong wind playing over a porous surface would set up a suction effect comparable to that familiar in atomizers, an effect which would result in a slight elevation of the sprayladen wind above the short spring growth slightly depressed in the shrub mass. A similar effect would keep the spray from falling behind the shrub mass, permitting the leeward lateral shoots to grow unimpeded. This phenomenon means that during the period of strong winds from the sea. there is set up a ground air current toward the sea. This air moves up through the interlacing branches and not only keeps the spray from settling into the shrubs but actually elevates the spray-laden wind slightly above their sloping surfaces. This effect is naturally most pronounced nearest the sea where the wind velocity is the highest, and where the spray is most concentrated.

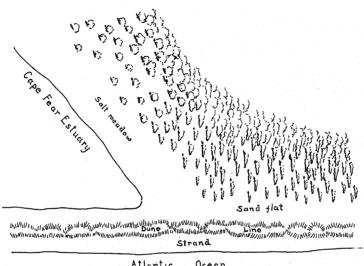
At the same period in which all of the foregoing observations were made, we were able to produce exactly the same type of injury by spraying healthy juvenile shoots of wax myrtle, yaupon and live oak once or twice with sea water, and with distilled water containing a 3 per cent concentration of sodium chloride. The injury patterns resulting in both cases were identical with that from sea spray.

In contrast to these observations attention should be called to the fact that, where the wind sweeps across the sound estuaries of fresh water with little less velocity than it does over the ocean, no noticeable modification of the shore woody plants is discernible. Careful examination of those on the west shore of the Chowan River, 2 miles in width, showed not the slightest deviation from a uniformly symmetrical form among all the woody plants.

From the foregoing evidence, it is clear that a complete revaluation of the wind factor in coastal plant ecology must be made. Certainly on the coast of the Cape Fear peninsula, we can state categorically that the socalled "wind formed" shrubs are not wind formed at all but owe their marked modification wholly to the killing action of the salt on the tender shoots during their growing period. These coastal malformed shrubs should therefore be called "spray forms."

NATURE OF THE INJURY

It may be assumed that, during the day-time exposure to spray, the concentration of the chlorides deposited on the plants is always higher than that of the sea water, owing to the rapid evaporation of the water by the high wind occurring at that time.



Atlantic Ocean

Fig. 3. Section of coast south of Fort Fisher, N. C. Slope form shrubs only in spray zone. Those exposed to wind across estuary but beyond spray zone are of normal form.

Since killing of very young tissues of the new shoots could readily be induced by one or two applications of sea water in the day period it is clear that the longer spray exposure would result in severe injury to the immature tissues. Only the adult stems and leaves escape in the case of the plants found in the stronger spray zones.

The injury may thus be interpreted as necrosis due to excessive water loss from the young tissues resulting from the osmotic action of high salt concentrations on the unprotected surfaces.

DIFFERENTIAL RESISTANCE OF COASTAL PLANTS

The most resistant woody plant is the water bush (Baccharis halimifolia). This fact, however, does not necessarily mean that this shrub will be found nearest to the sea, because its distribution is also partly controlled by the depth of the water table. It is never seen growing on the dry sides of dunes or even slightly elevated areas. Next in order of resistance are the yaupon (*Ilex vomitoria*) and the wax myrtle (*Myrica cerifera*) which are equally tolerant of salt spray; they are frequently seen merged in common shrub masses.

The only tree on the sea front associated with the shrubs mentioned is the live oak (Quercus virginiana) which, assuming a compact shrub-form, is sparingly scattered in the fully exposed zone, but occurs for the most part protected by one or more of the preceding shrubs. On the coast facing northeast, in the vicinity of Kitty Hawk, a shift in the dunes occasionally leaves a live oak exposed to the full force of the ocean wind with its high content of salt spray. This results in a completely one-sided development (fig. 2); new growth being impossible on the spray exposed side, the tender shoots survive only on the protected side of the tree. Such trees show the maximum attainment of the spray form.

Most sensitive of all the arborescent species surviving in the spray zone is the loblolly pine (*Pinus Taeda*). An occasional low specimen was noted in the front zone, but it was always behind a protecting shrub mass.

Through field observations and many tests we found that the young growth of loblolly pine was readily killed under weak spray intensity, but the mature leaves either of the current season or a year old were somewhat resistant. There is a lag in the appearance of the characteristic light sienna color of the necrotic leaves following the application of the salt water. Their tips first show the injury, the necrosis rapidly progressing stemward until the leaves are completely killed. This is then followed by dehiscence of the branch. The observed behavior of the leaves artificially sprayed and dipped in sea water checked with conditions found in the field. In the Fort Fisher area, *Pinus Taeda*, characterized by a slight resistance to the salt, dominated the inner and weaker spray zone.

The only five woody plants occurring and persisting in the spray zone listed in the order of their resistance are water bush, yaupon and myrtle, live oak, and loblolly pine.

Observations on a few representatives of more inland woody plants (persimmon, turkey oak, grape) which by chance were close enough to the sea to be injured showed such a severity of injury to the practically mature leaves that the explanation of their almost complete absence from the spray zones was apparent.

Extensive areas of the turkey oak (Quercus Catesbaei) occur along the coast near the sea. Why these trees, so perfectly adapted to the sand soil

habitat, never were found competing with the woody plants of the seaside, had been puzzling to ecologists. Our observations solve this problem. The leaves of this tree cannot even tolerate the weak spray of the inner zone, which is withstood by the pine.

In all of the woody plants except the pines, branch regeneration from lateral buds occurred throughout the growing season. The new growth was not confined to the spring period. Thus the degree of fastigiation in any particular zone is related to the frequency of high winds with their high spray content.

SPRAY ZONE WIDTH

Having learned that the loblolly pine along the coast was the most sensitive of the woody plants able to survive in the weak or landward side of the spray zone, we were able to use this tree as an index in measuring the width of the spray zone at various points along the coast. Myrtle Beach, South Carolina, showed the narrowest width (lowest winds) with a measurement of .1 mile. The Orrell line road transect near Fort Fisher gave .3 mile. The widest spray zone perhaps on the entire coast was that noted at Kitty Hawk on the northeast-facing coast below Norfolk where injury was apparent 1.25 miles inland.

SALT SPRAY AND THE DUNE COMMUNITY

From the observations presented on the restricted number of woody plants able to survive in the salt spray zone compared to the number of woody plants which cannot exist in this zone, it would seem to follow that the same contrast must obtain in relation to the dominantly herbaceous dune community. And this would be especially true since this community occupies the heaviest spray zone of all, that next the strand. To test this matter we transplanted a clump of wire grass (Aristida stricta) from an inland sandhill community dominated by long leaf pine and turkey oak to a dune top on April 3. On April 9 almost all the leaves had been killed nearly to the base, and on April 30 the plant gave evidence of being completely dead. Another clump placed 30 yeards inland from the strand showed little injury during the month's exposure.

It seems probable that the distinctive composition of the dune community is based primarily upon the species adaptations to the spray factor. However, much more work must be done on this phase of the problem before a completely satisfactory evaluation of the front dune factor complex may be reached.

SUMMARY

Observations made during the spring of 1937 prove that the repressed

sloping forms of the seaside shrubs ("wind forms" of the literature) are not due to wind but to the killing action of salt spray on the young growing shoots. Such form modifications should therefore be called "spray forms."

Based upon the death within a month's period of Aristida stricta transplanted from an inland habitat to the front dunes, it is suggested that the dominants of the ocean dune community are dominant because of their resistance to salt spray.

INDEX TO AMERICAN BOTANICAL LITERATURE FOR OCTOBER BULLETIN

- Aikman, J. M. & Smelser, A. W. The structure and environment of forest communities in central Iowa. Ecology 19: 141-150. f. 1-3. Ja 1938.
- Albaum, H. G. Inhibitions due to growth hormones in fern prothallia and sporophytes. Am. Jour. Bot. 25: 124-133. f. 1-43. 10 F 1938.
- Albers, V. M. & Knorr, H. V. Absorption spectra of single chloroplasts in living cells in the region from 664 m μ to 704 m μ . Plant Physiol. 12: 833-843. f. 1-10. Jl 1937.
- Alexander, E. J. Bark and buds to identify some native trees in winter, Jour. N. Y. Bot. Gard. 39: 61-68. Mr 1938.
- Allard, H. A. Linum lewisii and Bouteloua curtipendula in West Virginia. Castanea 3: 13, 14. F 1938.
- Allington, W. B. The separation of plant viruses by chemical inactivation. Science 87: 263. 18 Mr. 1938.
- Andrews, A. L. A new Sphagnum from New Guinea. Bryologist 40: 36-38. pl. 4. Mr-Ap 1937.
- Applegate, E. I. Plants of the Lava Beds National Monument, California. Am. Midl. Nat. 19: 334-367. f. 1-6. Mr. 1938.
- Armilaze, E. Some Spitsbergen mosses. Bryologist 40: 74-78. Jl-Au 1937.
- Arndt, C. H. Water absorption in the cotton plant as affected by soil and water temperatures. Plant Physiol. 12: 703-720. Il 1937.
- Backeberg, C. Colored Cereae. Jour. Catus & Succ. Soc. Am. 9: 89-92. illust. D 1937.
- Bailey, L. H. Thrinax. Gentes Herb. 4: 129-149. f. 75-85. Mr 1938.
- Bain, H. F. Production of synthetic mycorrhiza in the cultivated cranberry. Jour. Agr. Res. 55: 811-835. pl. 1-10. D 1937.
- Baines, R. C. Mint anthracnose. Phytopathology 28: 103–113. f. 1–4. F 1938.
- Ball, C. R. The willows of the southern states. Castanea 3: 1-9. Ja 1938.
- Barkley, F. A. & Barkley, E. D. A short history of *Rhus* to the time of Linnaeus. Am. Midl. Nat. 19: 265-333. f. 1-27. Mr 1938.
- Beck, W. A. Development of carotenoid pigments without the aid of light. Plant Physiol. 12: 885-886. Jl. 1937.
- Bonner, J. & Bonner, D. Ascorbic acid and the growth of plant embryos. Proc. Nat. Acad. Sci. 24: 70-75. f. 1, 2. F 1938.

- Brooks, C. & McColloch, L. P. Some effects of storage conditions on certain diseases of lemons. Jour. Agr. Res. 55: 795-809. f. 1-12. D 1937.
- Brown, M. S. Mosses from Syria. Bryologist 40:84, 85. S-O 1937.
- Cain, S. A. & Penfound, W. T. Aceretum rubri: the red maple swamp forest of central Long Island. Am. Midl. Nat. 19: 390-416. Mr 1938.
- Caldwell, J. & James, A. L. The propagation of tobacco plants from root cuttings. Phytopathology 28: 229, 230. f. 1. Mr 1938.
- Campbell, W. A. Decay hazard resulting from ice damage to northern hardwoods. Jour. Forest. 35: 1156–1158. D 1937.
- Carl, G. C. Flora and fauna of brackish water. Ecology 18: 446-453. f. 1-3. Jl 1937.
- Chase, A. New grasses from Oregon. Jour. Washington Acad. Sci. 28: 51-55. f. 1, 2. 15 F 1938.
- Chavan, A. R. A new species of *Cyathodium* from India. Bryologist 40: 57-60. pl. 5. My-Je 1937.
- Clark, H. W. Association types in the north coast ranges of California. Ecology 18²: 214–230. f. 1–5. Ap 1937.
- Clausen, R. T. A monograph of the Ophioglossaceae. Mem. Torrey Club 19³: 1-77. f. 1-33. 1938.
- Clausen, R. T. Ophioglossum petiolatum Hooker. Am. Fern Jour. 28: 1-11. pl. 1-3. Ja-Mr 1938.
- Clayton, E. E. Water soaking of leaves in relation to development of the blackfire disease of tobacco. Jour. Agr. Res. 55: 883-889. f. 1-5. 15 D 1937.
- Conard, H. S. The foray in upper Michigan, 1937. Bryologist 41: 18-22. F 1938.
- Cooper, H. P., Paden, W. R. & Smith, R. L. Intensity of removal of cations from cotton, corn, and soy bean tissue by fractional electrodialysis. Plant Physiol. 12: 979-987. f. 1. O 1937.
- Crandall, B. S. A root and collar disease of pine seedlings caused by *Spaeropsis ellisii*. Phytopathology **28**: 227–229. Mr 1938.
- Croizat, L. A misinterpreted Formosan species, *Euphorbia calonesiaca*, spec. nov. Jour. Arnold Arbor. 19: 97, 98. Ja 1938.
- Croizat, L. On the classification of *Euphorbia*. I. How important is the cyathium? Bull. Torrey Club 63: 525-531. D 1936.
- Dearness, J. The background of mycology and of Mycologia. Mycologia 30: 111-119. portrait. 1 Ap 1938.

- **Dodge, B. O.** Material for demonstrating the essential features of a Basidiomycete. Mycologia **30**: 133-136. f. 1, 2. 1 Ap 1938.
- Dodge, B. O. & Seaver, B. The combined effects of the dominant and the recessive lethals for ascus abortion in *Neurospora*. Am. Jour. Bot. 25: 156-166. f. 1-7. 21 Mr 1938.
- Drechsler, C. New Zoopogaceae capturing and consuming soil amoebae. Mycologia 30: 137-157. f. 1-4. 1 Ap 1938.
- Earle, T. T. Origin of the seed coats in *Magnolia*. Am. Jour. Bot. 25: 221, 222. f. 1-3. 21 Mr 1938.
- Eigisti, O. J. A cytological study of colchicine effects in the induction of polyploidy in plants. Proc. Nat. Acad. Sci. 24: 56-63. f. 1-36. F 1938.
- Ellison, L. & Woodfolk, E. J. Effects of drought on vegetation near Miles City, Montana. Ecology 18: 329–336. f. 1–4. Jl 1937.
- Emerson, R. A new life cycle involving cyst-formation in Allomyces. Mycologia 30: 120-132. f. 1-11. 1 Ap 1938.
- Emerson, S. The genetics of self-incompatibility in *Oenothera* organensis. Genetics 23: 190-202. f. 1-8. Mr 1938.
- Evans, A. W. A history of the genera *Nardia* and *Plectocolea*. Ann. Bryol. 10: 36-42. F 1938.
- Evans, A. W. A history of the genus *Pallavicinia*. Bryologist 40: 27-33. Mr-Ap 1937.
- Evans, A. W. The structure of the capsule wall in certain species of *Riccardia*. Ann. Bryol. 10: 20-30. f. 1-6. F 1938.
- Farwell, O. A. Rare plants in Michigan. Rhodora 40: 134-136. Mr 1938.
- **Fellows, H.** Interrelation of take-all lesions on the crowns, culms, and roots of wheat plants. Phytopathology **28**: 191–195. *f.* 1, 2. Mr 1938.
- Fleming, J. A. The effect of spectral regions on the chlorophyll "A" to "B" ratio. Science 87: 214. 4 Mr 1938.
- Flowers, S. Physcomitrium pygmaeum. Bryologist 40: 80. S-O 1937.
- Frye, E. M. Curious plants from the waysides of the Southwest. Jour. Cactus & Succ. Soc. Am. 9: 127-132. illust. F 1938.
- **Fulton, H. J.** Hopi cotton, a variable species. Jour. Agr. Res. 56: 333-336. f. 1, 2. 1 Mr 1938.
- Graham, E. H. Notes on some mosses from the Uinta Basin, Utah. Bryologist 40: 40-47. Mr-Ap 1937.
- Greenman, J. M. Taxonomy as a field for research. Science II. 87: 265, 266. 25 Mr 1938.

- Grout, A. J. Marshall Avery Howe. Bryologist 40: 33-36. pl. 3. Mr-Ap 1937.
- Groves, A. B. The relation of concentration of fungicides and bud development to control peach leaf curl. Phytopathology 28: 170-179. f. 1. Mr 1938.
- Guthrie, J. D. A new method for the determination of glutathione in tissues based on its reaction with sulphur to form hydrogen sulphide. Contr. Boyce Thompson Inst. 9: 223–232. f. 1. Ja-Mr 1938.
- Guthrie, J. D. The utilization of sulphate in the synthesis of glutathione by potato tubers following treatment with ethylene chlorhydrin. Contr. Boyce Thompson Inst. 9: 233-238. Ja-Mr 1938.
- Guthrie, J. D. Effect of ethylene thiocyanohydrin, ethyl carbylamine, and indoleacetic acid on the sprouting of potato tubers. Contr. Boyce Thompson Inst. 9: 265-272. f. 1, 2. Ja-Mr 1938.
- Haas, A. R. C. Factors in varietal susceptibility of walnut fruits to attack by the Walnut-husk fly. Plant Physiol. 12: 721-736. f. I-6. Jl 1937.
- Hammer, G. W. A method for finding the free water in plant tissue. Science 87: 263, 264. 18 Mr 1938.
- Hanna, W. F. The association of bunt with loose smut and ergot. Phytopathology 28: 142–146. f. 1. F 1938.
- Hanson, H. C. Ecology of the grasslands. Bot. Rev. 4: 51-82. F 1938.
- Hanson, H. C. & Whitman, W. Plant succession on Solonetz soils in western North Dakota. Ecology 18⁴: 516-522. f. 1-4. O 1937.
- Harper, R. M. Palms of the southern Appalachian region in Alabama. Castanea 3: 18-24. f. 1, 2. F 1938.
- Harper, R. M. "Frost-flower" plants in Alabama. Torreya 38: 1-4. Ja-F 1938.
- Harrar, J. G. Factors affecting the pathogenicity of Fomes lignosus Klotazsch. Univ. Minnesota Agr. Exp. Sta. Tech. Bull. 123: 1–28. f. 1–9. D 1937.
- Henderson, R. G. Studies on tobacco downy mildew in Virginia Virginia Polytech. Inst. Tech. Bull. 62: 3-19. f. 1-8. N 1937.
- Hermann, F. J. New or otherwise interesting plants from Indiana. Rhodora 40: 76-86. illust. Mr 1938.
- Hirt, R. R. Relation of stomata to infection of *Pinus Strobus* by *Cronartium ribicola*. Phytopathology **28**: 180–190. f. 1, 2. Mr 1938.

- Hodgdon, A. R. Taxonomic study of *Lechea*. Rhodora 40: 29-69. pl. 488-491. F 1938; 87-131. Mr 1938.
- Homan, C. Effects of ionized air and ozone on plants. Plant Physiol. 12: 957-978. f. 1-5. O 1937.
- Hotson, J. W. & Stuntz, D. E. The genus Agaricus in western Washington. Mycologia 30: 204-239. f. 1-12. 1 Ap 1938.
- Irwin, M. R. Immuno-genetic studies of species relationships in Columbidae. Jour. Genetics 35: 351–373. f. 1–7. F 1938.
- Jenkins, A. E. & Bitancourt, A. A. Doenças das plantas causadas por fungos dos generos *Elsinoe* e *Sphaceloma*. Rodriguesia 2: Spec. No. 305–313. f. 1. 1936.
- **Jenkins, W. A.** Two fungi causing leaf spot of peanut. Jour. Agr. Res. **56**: 317-332. *pl.* 1+f. 1-5. 1 Mr 1938.
- Jensen, P. B. Growth hormones in plants. i-xiv. 1-268. f. 1-64. McGraw-Hill Book Co. New York. 1936.

Translated and revised by G. S. Avery and P. R. Burkholder. Including 188 new contributions to the literature and 40 additional illustrations.

- Johnson, D. S. & Chrysler, M. A. Structure and development of *Regnellidium diphyllum*. Am. Jour. Bot. 25: 141-156. f. 1-57. 21 Mr 1938.
- Johnson, E. L. & Burke, M. M. Tuber production of the Colorado wild potato as influenced by certain environmental factors. Ecology 18: 432-438. f. 1-5. Jl 1937.
- Johnston, C. O., Lefebvre, C. L. & Hansing, E. D. Observations on the loose kernel smut of Johnson grass. Phytopathology 28: 151, 152. F 1938.
- Johnston, E. S. Sun rays and plant life. Smithsonian Rep. 353-371. f. 1-8.+pl. 1-4. 1936.
- Jones, L. M. Decorative algae on the crab, Naxia tumida. Ecology 19: 81-88. f. 1-8. Ja 1938.
- Judd, B. I. Agropyron Smithii. Ecology 18: 547. O 1937.
- Kadow, K. J., Anderson, H. W. & Hopperstead, S. L. Control of *Sclerotinia* and *Botrytis* stem rots of greenhouse tomatoes and cucumbers. Phytopathology 28: 224-227. f. 1. Mr 1938.
- Karling, J. S. Fungi of British Honduras. I. Ann. Myc. 34: 1-10. pl. 1-3. 1936.
- Karling, J. S. A new chytrid genus, *Nephrochytrium*. Am Jour. Bot. 25: 211-215. f. 1, 2. 21 Mr 1938.
- Kertesz, Z. I. On the determination of plant enzymes. Plant Physiol. 12: 845-851. Jl 1937.
- Kinman, C. F. An orange-colored bud sport of the Agen plum. Jour. Heredity 28: 419, 420. f. 16. D 1937.

- Kikuta, K., Whitney, L. D., & Parris, G. K. Seeds and seedlings of the taro, *Colocasia esculenta*. Am. Jour. Bot. 25: 186. f. 1, 2. 21 Mr 1938.
- Knaysi, G. Cytology of bacteria. Bot. Rev. 4: 83-112. F 1938.
 Kol, E. Some new snow algae from North America. Jour. Washington Acad. Sci. 28: 55-58. f. 1, 2. 15 F 1938.
- Koehler, B. Fungus growth in shelled corn as affected by moisture. Jour. Agr. Res. 56: 291-307. f. 1-5. 15 F 1938.
- Kramer, P. J. Root resistance as a cause of the absorption lag. Am. Jour. Bot. 25: 110-113. f. 1-3. 10 F 1938.
- La Motte, R. S. Climatic implications of Sapindus oregonianus. Carnegie Inst. Publ. 455: 31-38. pl. 1-3. O 1936.
- La Motte, R. S. The Miocene Tilias of western America. Carnegie Inst. Publ. 455: 41-48. pl. 1-3. O 1936.
- La Motte, R. S. Some systematic revisions in Miocene Palaeobotany, 1934-36. (Suppl.) Carnegie Inst. Publ. 455: 145-148. O 1936.
- La Motte, R. S. The upper Cedarville flora of northwestern Nevada and adjacent California. Carnegie Inst. Publ. 455: 57-142. pl. 1-14. +f. 1-3. O 1936.
- La Motte, R. S. An upper Oligocene florule from Vancouver Island. Carnegie Inst. Publ. 455: 49-56. pl. 1. O 1936.
- Leonard, O. A. Transformation of sugar in sugar beet and corn leaves and invertase activity. Am. Jour. Bot. 25: 78-83. 10 F 1938.
- Little, E. L. Bryophytes of the Jornada Experimental Range, New Mexico. Bryologist 40: 81-83. S-O 1937.
- Little, E. L. Flora of Muskogee County, Oklahoma. Am. Midl. Nat. 19: 369-389. Mr 1938.
- Little, E. L. A study of poisonous *Drymaria* on southern New Mexico ranges. Ecology 18³: 416-426. f. 1-4. Jl 1937.
- Lockwood, L. B. & Moyer, A. J. The production of chemicals by filamentous fungi. Bot. Rev. 4: 140-164. Mr 1938.
- McFarlin, J. B. Mosses of Polk County, Florida. Bryologist 40: 49-57. My-Je 1937.
- MacGinitie, H. D. The flora of the Weaverville beds of Trinity County, California. Carnegie Inst. Publ. 465: 83-151. f. 1-5. 1937.
- Mackinney, G. Chlorophyll in Sultanian grapes and raisins. Plant Physiol. 12: 1001-1004. O 1937.
- MacLachlan, J. D. A rust of the pimento tree in Jamaica, B. W. I. Phytopathology 28: 157-179. f. 1-3. Mr 1938.
- McLean, F. T. A genetic analysis of the inheritance of fragrance of gladiolus. Bull. Torrey Club 65: 181-197. Mr 1938.

- McVaugh, R. Some aspects of plant distribution in the Hudson River Estuary. Bartonia 17: 13-16. 2 Ap 1936.
- Merrill, E. D. & Walker, E. H. A bibliography of eastern Asiatic botany, i-xlii, 1-719. Jamaica Plain, Mass. Arnold Arbor. 1938.
- Mielke, J. L. An example of the ability of *Ribes lacustre* to intensify *Cronartium ribicola* on *Pinus monticola*. Jour. Agr. Res. 55: 873–882. f. 1, 2. 15 D 1937.
- Miller, C. Male Plant of *Polytrichadelphus Lyallii*. Bryologist 40: 87-89. f. 1-9. S-O 1937.
- Miller, J. H. Studies in the development of two *Myriangium* species and the systematic position of the order Myriangiales. Mycologia 30: 158–181. f. 1–4. 1 Ap 1938.
- Miller, L. P. Evidence that plant tissue forms a chlorine-containing B-glucoside from ethylene chlorhydrin. Cont. Boyce Thompson Inst. 9: 213-221. Ja-Mr 1938.
- Moldenke, H. N. A monograph of the genus *Petrea*. Repert Spec. Nov. 43: 1-48. 10 Ja 1938; 161-221. 1 F 1938.
- Moore, B. Buried forests in bogs of southwestern Ireland—A correction. Ecology 18²: 328. Ap 1937.
- Moore, J. W. Euphorbia dentata and Salsola collina in Minnesota. Rhodora 40: 135, 136. Mr 1938.
- Moxley, E. A. Bryological notes from Owen Sound and Bruce Peninsula. Bryologist 40: 89-90. S-O 1937.
- Mrak, E. M. & Bonar, L. The effect of temperature on asci and ascospores in the genus *Debaryomyces*. Mycologia 30: 182–186. f. 1, 2. 1 Ap 1938.
- Nelson, R. C. The quantity of ethylene present in apples. Plant Physiol. 12: 1004, 1005. O 1937.
- Norton, H. W. Note on Smith's paper on stoma number. Am. Jour. Bot. 25: 216, 217. 21 Mr 1938.
- Oliver, E. A. A Miocene flora from the Blue Mountains, Oregon. Carnegie Inst. Publ. 455: 1-27. pl. 1-5. O 1936.
- Oosting, H. J. The vegetation of a barefaced cliff in western North Carolina. Ecology 18²: 280-292. f. 1-12. Ap 1937.
- Osterhout, W. J. V. Potentials in *Halicystis* as affected by non-electrolytes. Proc. Nat. Acad. Sci. 24: 75-79. F 1938.
- Overholts, L. O. Notes on fungi from the lower Mississippi Valley. Bull. Torrey Club. 65: 167-180. f. 1-13. Mr 1938.
- Palmquist, E. M. The simultaneous movement of carbohydrates and fluorescein in opposite directions in the phloem. Am. Jour. Bot. 25: 97-105. f. 1-5. 10 F 1938.
- Parker, D. Some liverworts from Indiana. Bryologist 40: 79, 80. S-O 1937.

- Pechanec, J. F., Pickford, G. D. & Stewart, G. Effects of the 1934 drought on native vegetation on the Upper Snake River Plains, Idaho. Ecology 184: 490-505. O 1937.
- Pennell, F. W. Castilleja in the Charleston mountains, Nevada. Proc. Nat. Acad. Sci. 89: 419-424. 1937.
- Pennell, F. W. Taxonomy and distribution of *Aragoa*, and its bearing on the geological history of the northern Andes. Proc. Nat. Acad. Sci. 89: 425-432. *illust.* 1937.
- Pfeiffer, N. E. Viability of stored *Lilium* pollen. Contr. Boyce Thompson Inst. 9: 199-211. f. 1-3. Ja-Mr 1938.
- Popp, H. W. & McIlvaine, H. R. C. Growth substances in relation to the mechanism of the action of radiations on plants. Jour. Agr. Res. 55: 931-936. 15 D 1937.
- Powers, L. & Clark, A. Failure of chromosome pairing as evidence of secondary diploidy in *Zea Mays*. Jour. Genetics 35: 301-313. N 1937.
- Pratt, R. & Trelease, S. F. Influence of deuterium oxide on photosynthesis in flashing and in continuous light. Am. Jour. Bot. 25: 133-139. f. 1-5. 10 F 1938.
- Record, S. J. The American woods of the orders Celastrales, Olacales, and Santalales. Trop. Woods 53:11-38. M 1938.
- Reed, H. S. Cytology of leaves affected with little-leaf. Am. Jour. Bot. 25: 174-186. f. 1-17. 21 Mr 1938.
- Reinking, O. A. Lightning injury in banana plantations. Phytopathology 28: 224. f. 1. Mr 1938.
- Renn, A. E. The eel-grass situation along the middle Atlantic coast. Ecology 18: 323-325. Ap 1937.
- Rosen, H. R. Life span and morphology of fire blight bacteria as influenced by relative humidity, temperature, and nutrition. Jour. Agr. Res. 56: 239-258. pl. 1-3. 15 F 1938.
- Scott, F. M. Root system and root nodules of the seedling smoke tree, *Parosela spinosa*. Ecology 19: 166-168. Ja 1938.
- Senn, H. A. Experimental data for a revision of the genus Lathyrus. Am. Jour. Bot. 25: 67-78. f. 1-56. 10 F 1938.
- Setchell, W. A. Hong Kong seaweeds. V. Sargassaceae. Hong Kong Nat. (Suppl.) 5: 1-20. pl. 1-8. Je 1936.
- Setterstrom, C., Zimmerman, P. W. & Crocker, W. Effect of low concentrations of sulphur dioxide on yield of alfalfa and Cruciferae. Contr. Boyce Thompson Inst. 9: 179–198. Ja-Mr 1938.
- Shank, C. K. The leaf and stem anatomy of Cornus florida in relation to light exposure. Am. Midl. Nat. 19: 417-426. Mr 1938.

- Shreve, F. & Hinckley, A. L. Thirty years of change in desert vegetation. Ecology 18: 463-478. O 1937.
- Shurtleff, R. Rotrychium dissectum. Am. Fern Jour. 28: 25-28. f. 1, 2. Ja-Mr 1938.
- Sideris, C. P. Krauss, B. H. & Young, H. Y. Assimilation of ammonium and nitrate nitrogen from solution cultures by roots of *Pandanus Veitchii* Hort. and distribution of the various nitrogen fractions and sugars in the stele and cortex. Plant Physiol. 12: 899–928. f. 1–8. O 1937.
- Silveira Grillo, H. V. Lista preliminar dos fungos assignalados em plantas do Brasil. Rodriguesia 2: 39-96. 1937.
- Silveira, F. Caryologia e taxinomia. Rodriguesia 2: 73-75. Ie-S 1937.
- Silveira, F. Joaquim monteiro Caminhoa. Rodriguesia 2: 101-105. Je-S 1937.
- Sirks, M. J. Plasmatic inheritance. Bot. Rev. 4: 113-131. Mr 1938.
- Sisson, W. A. Orientation in young cotton fibers as indicated by x-ray diffraction studies. Contr. Boyce Thompson Inst. 9: 239-248. f. 1-3. Ja-Mr 1938.
- Smith, C. O. Crown gall on *Taxus baccata*. Phytopathology 28: 153-155. f. 1. F 1938.
- Smith, D. C. Occurrence of albino seedlings in Victoria oats. Jour. Heredity 29: 63, 64. f. 7. F 1938.
- Smith, F. H. Some chromosome numbers in the Cruciferae. Am. Jour. Bot. 25: 220, 221. f. 1-12. 21 Mr 1938.
- Smith, G. Nuclear phases and alternation of generations in the Chlorophyceae. Bot. Rev. 4: 132–139. Mr 1938.
- Smith, W. M. & ZoBell, C. E. Direct microscopic evidence of an autochtonous bacterial flora in Great Salt Lake. Ecology 18³: 453-458. Jl 1937.
- Snell, W. H. Notes on Boletes. V. Mycologia 28: 463-475.
 1 O 1936.
- Spencer, E. L. Influence of host nutrition on systemic development of tobacco mosaic. Plant Physiol. 12: 825-832. Il 1937.
- Spencer, E. L. Seasonal variations in susceptibility of tobacco to infection with tobacco-mosaic virus. Phytopathology 28: 147-150. f. 1, 2. F 1938.
- Spencer, E. L. & McNew, G. L. The influence of mineral nutrition on the reaction of sweet-corn seedlings to *Phytomonas stewarti*. Phytopathology 28: 213-223. f. 1-3. Mr 1938.

- Stacey, J. W. Notes on Carex. X. Leafl. West. Bot. 2: 39, 40. 26 Au 1937; XI. 63, 64. 20 N 1937; XII. 80. Ja 1938.
- Stebbins, G. L. Cytological characteristics associated with the different growth habits in the dicotyledons. Am. Jour. Bot. 25: 189-197. f. 1. 21 Mr 1938.
- Steere, W. C. Bryoxiphium norvegicum, the sword moss, as a preglacial and interglacial relic. Ecology 18: 346-358. f. 1. Jl 1937.
- Steinbauer, G. P. Dormancy and germination of Fraxinus seeds. Plant Physiol. 12: 813-824. f. 1-6. Jl 1937.
- Steinberg, R. A. Role of molybdenum in the utilization of ammonium and nitrate nitrogen by Aspergillus niger. Jour. Agr. Res. 55: 891-902. 15 D 1937.
- Steward, F. C. & Martin, J. C. The distribution and physiology of *Valonia* at the Dry Tortugas, with special reference to the problem of salt accumulation in plants. Carnegie Inst. Publ. 475: 87-170. pl. 1, 2+f. 1-4. O 1937.
- Steyermark, J. A. Validation of combinations in Palmer and Steyermark's annotated catalogue of the flowering plants of Missouri. Rhodora 40: 131–134. Mr 1938.
- Stillinger, C. R. Distribution, hosts and internal telia of Puccinia Parkerae. Mycologia 30: 235-242. f. 1, 2. 1 Ap 1938.
- Stoudt, H. N. Gemmipary in Kalanchoe rotundifolia and other Crassulaceae. Am. Jour. Bot. 25:106-110. f. 1-7. 10 F 1938.
- Tharp, W. H. A sand-nutrient infection technique for study of fusarium wilt of cotton. Phytopathology 28: 206-209.
- Thomas, W. Foliar diagnosis: principles and practice. Plant Physiol. 12: 571-599. f. 1-7. Jl 1937.
- Thompson, J. W. Northwestern botany notes. I. Leafl. West. Bot. 1: 211-213. 24 Ap 1936.
- Thompson, R. C. & Kosas, W. F. The germination of lettuce seed stimulated by chemical treatment. Science 87: 218, 219. 4 Mr 1938.
- Thornberry, H. H. Pectase activity of certain microorganisms.

 Phytopathology 28: 202-205. Mr 1938.
- Thornberry, H. H., Valleau, W. D. & Johnson, E. M. Inactivation of tobacco-mosaic virus in cured tobacco leaves by dry heat. Phytopathology 28: 129-134. F 1938.
- True, R. H. Lichens from the New England coast. Bryologist 40: 71-73. Jl-Au 1937.
- Utter, L. G. Culture and inoculation studies on races of the loose and covered smuts of oats. Am. Jour. Bot. 25: 198–210. f. 1–21. 21 Mr 1938.

- Vanscoy, E. M. Some famous West Virginia trees. Castanea 3: 14-18. F 1938.
- Vestal, A. G. A subject index for communities, including vegetation-components. Ecology 19: 107–125. Ja 1938.
- Voegele, A. C. Effect of environmental factors upon the color of the tomato and the watermelon. Plant Physiol. 12: 929-955. f. 1-17. O 1937.
- Wallace, R. H. Methods of sampling visible radiation. Plant Physiol. 12: 647–666. f. 1–10. Jl 1937.
- Wallace, R. H. & Clum, H. H. Leaf temperatures. Am. Jour. Bot. 25: 83-97. f. 1-7. 10 F 1938.
- Walther, E. Echeveria hybrids. Jour. Cactus & Succ. Soc. Am. 9:92, 93. f. 1-3. D 1937.
- Watkins, G. M. Cytology of *Phymatotrichum* root rot of cotton seedlings grown in pure culture. Am. Jour. Bot. 25: 118–124. f. 1–21. 10 F 1938.
- Watkins, G. M. Histology of *Phymatotrichum* root rot of field-grown cotton. Phytopathology 28: 195–202. f. 1. Mr 1938.
- Went. F. W., Bonner, J. & Warner, G. C. Aneurin and the rooting of cuttings. Science 87: 170, 171. 18 F 1938.
- Wherry, E. T. Midland fern notes. Am. Fern Jour. 28: 28-30. Ja-Mr 1938.
- Wherry, E. T. & Constance, L. A new phlox from the Snake River Canyon Idaho-Oregon. Am. Midl. Nat. 19: 433-435. f. 1, 2. Mr 1938.
- White, P. R. Amino acids in the nutrition of excised tomato roots. Plant Physiol. 12: 793-802. f. 1-5. Jl 1937.
- White, P. R. "Root-pressure"—An unappreciated force in sap movement. Am. Jour. Bot. 25: 223–227. f. 1–6. 21 Mr 1938.
- White, P. R. Vitamin B in the nutrition of excised tomato roots. Plant Physiol. 12: 803-811. f. 1-5. Jl 1937.
- White, P. R. Separation from yeast of materials essential for growth of excised tomato roots. Plant Physiol. 12: 777-791. f. 1-11. Jl 1937.
- White, P. R. Survival of isolated tomato roots at suboptimal and supraoptimal temperatures. Plant Physiol. 12: 771–776. f. 1. Jl 1937.
- White, W. L. & Whetzel, H. H. Pleomorphic life cycles in a new genus of the Helotiaceae. Mycologia 30: 187–203. f. 1–21. 1 Ap 1938.
- Whitfield, C. J. & Beutner, E. L. Natural vegetation in the desert plains grasslands. Ecology 19: 26-37. f. 1-4. Ja 1938.

- Williams, L. Forest trees of the Isthmus of Tehuantepec, Mexico. Trop. Woods 53: 1-11. Mr 1938.
- Willison, R. S. Peach canker investigations. II. Infection studies. Canadian Jour. Res. 14: 27-44. pl. 1-3. Ja 1936.
- Wilson, E. E. Control of peach leaf curl by autumn applications of various fungicides. Phytopathology 27: 110-112. Ja 1937.
- Wilson, J. D. & Livingston, B. E. Lag in water absorption by plants in water culture with respect to changes in wind. Plant Physiol. 12: 135-150. f. 1-3. Ja 1937.
- Wilson, J. K. Scarification and germination of black locust seeds. Jour. Forest. 35: 241-246. Mr 1937.
- Wilson, L. R. A quantitative and ecological study of the larger aquatic plants of Sweeney Lake, Oneida County, Wisconsin. Bull. Torrey Club 64: 199-208. f. 1, 2. Ap 1937.
- Wilson, L. R. & Galloway, E. F. Microfossil succession in a bog in northern Wisconsin. Ecology 18: 113-118. f. 1-3. Ja 1937.
- Wilton, O. C. & Roberts, R. H. Anatomical structure of stems in relation to the production of flowers. Bot. Gaz. 98: 45-64. f. 1-43. 30 S 1936.
- Wingo, S. M. The family Tortulaceae in Tennessee. Bryologist 39: 35-39. My-Je 1936.
- Wipf, L. & Cooper, D. C. Chromosome numbers in nodules and roots of red clover, common vetch and garden pea. Proc. Nat. Acad. Sci. 24: 87-91. f. 1-6. F 1938.
- Wirth, H. E. & Rigg, G. B. The acidity of the juice of Desmarestia. Am. Jour. Bot. 24: 68-70. F 1937.
- Withrow, R. B. & Benedict, H. M. Photoperiodic responses of certain greenhouse annuals as influenced by intensity and wavelength of artificial light used to lengthen the daylight period. Plant Physiol. 11: 225-249. f. 1-9. Ap 1936.
- Wodehouse, R. P. Pollen grains in the identification and classification of plants. VII. The Ranunculaceae. Bull. Torrey Club 63: 495-514. pl. 20. D 1936. VIII. The Alismataceae. Am. Jour. Bot. 23: 535-539. f. 1. O 1936.
- Wodehouse, R. P. Pollen in hayfever. Torreya 36: 77-86. pl. 1.

 Jl-Au 1936.
- Wodehouse, R. P. Toxic wind-borne pollen in its relation to hayfever. Jour. N. Y. Bot. Gard. 37: 177-185. f. 1-3. Au 1936.
- Wolcott, G. B. Chromosome numbers in the Convolvulaceae. Am. Nat. 71: 190-192. f. 1-8. Mr-Ap 1937.

- Wolcott, G. B. Cytological studies on the Hepaticae. I. Somatic mitosis in *Pallavicinia Lyellii*. Am. Jour. Bot. 24: 30-33. f. 1-12. 26 Ja 1937.
- Wolden, B. O. Additions to the lichen flora of Emmet County. Proc. Iowa Acad. Sci. 42:71. 1936.
- Wolf, F. T. A nutritional study of Achlya bisexualis and Saprolegnia ferax. Am. Jour. Bot. 24: 119-123. f. 1-3. Mr 1937.
- Wolf, F. T. Some sporangial variations in Saprolegnia ferax. Mycologia 29: 226-228. f. 1-6. Mr-Ap 1937.
- Wolf, F. A. & Gross, P. M. Flue-cured tobacco: a comparative study of structural responses induced by topping and suckering. Bull. Torrey Club 64: 117-131. f. 1, A-L. 1 M 1937.
- Wolf, F. A., McLean, R. A. & Dixon, L. F. Further studies on downy mildew of tobacco. Phytopathology 26: 760-777. f. 1-8. Au 1936.
- Wood, F. C. Studies on "damping off" of cultivated mushrooms and its association with *Fusarium* species. Phytopathology 27: 85-94. f. 1, 2. Ja 1937.
- Woodson, R. E. & Moore, J. A. The vascular anatomy and comparative morphology of apocynaceous flowers. Bull. Torrev Club 65: 135–166. f. 1–72. +pl. 3–5. Mr 1938.
- Woodson, R. E. New or otherwise noteworthy Apocynaceae of tropical America V. Ann. Missouri Bot. Gard. 24: 11-16. F 1937.
- Woodson, R. E. Studies in the Apocynaceae. V. Sunyatsenia 3: 65-105. My 1936. VI. Philippine Jour. Bot. 60: 205-229. pl. 1. Jl 1936.
- Woodward, C. H. Chiavenna. House & Gard. 71: 48, 49, 64, 66, 68. illust. F 1937.
- Woodward, C. H. Flowers of St. Moritz. House & Gard. 71: 62, 63, 88, 89. illust. Mr 1937.
- Woodward, C. H. Plants in the Adda Valley. House & Gard. 71: 29, 75-78. illust. Ja 1937.
- Worley, C. L. Carbohydrate changes within the needles of *Pinus ponderosa* and *Pseudotsuga taxifolia*. Plant Physiol. 12: 755-769. f. 1-5. Jl 1937.
- Wright, K. E. Effects of phosphorus and lime in reducing aluminum toxicity of acid soils. Plant Physiol. 12: 173-181. Ja 1937.
- York, H. H. Inoculations with forest tree rusts. Phytopathology 28: 210-212. f. 1. Mr 1938.
- Young, P. A. Sclerotium blight of wheat. Phytopathology 27: 1113-1118. f. 1, 2. N 1937.

TORREY BOTANICAL CLUB

OFFERS TO BOTANICAL LIBRARIES AND OTHERS wishing to keep in touch with the rapidly growing American botanical literature

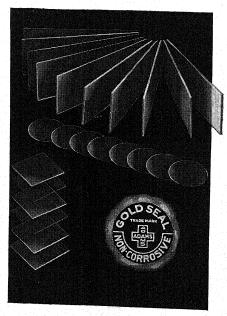
A CARD INDEX

of all botanical publications of the New World from 1893 to 1937. Each title is printed on a separate card in two sizes, $2'' \times 5''$ and $3'' \times 5''$, in library style, and is available at 3 cents each.

The cards are sold in sets covering any year in this period. Subscriptions for 1938 are open. The approximate number of cards for 1938 will be 1600. The estimated cost of the cards for this year will be \$48.

Address all inquiries to

Dr. HAROLD N. MOLDENKE, Treasurer Torrey Botanical Club, New York Botanical Garden Fordham Station, Bronx Park, New York City



MADE IN U.S.A.

The Standard for Microscope Glass

Gold Seal Microscope Slides and Cover Glasses

Crystal Clear · Non-Corrosive · Will Not Fog

Microscopic work demands glass of unusual clarity. Gold Seal Slides and Cover Glasses are made from glass practically free from alkali. They attain a precise and uniform thinness of plane surface. Therefore, Gold Seal offers an unusual degree of crystal clarity. Further, Gold Seal is guaranteed against corrosion, fogging or any imperfection. Specify Gold Seal Slides and Cover Glasses.



Spiral Systems in the Vascular Plants¹

JOHN H. SCHAFFNER (WITH PLATES 22 TO 24)

The sporophytes of vascular plants usually develop a radially symmetrical stem or axis from a meristematic mass of dividing cells. This radial symmetry depends on a fundamental potentiality possessed by the interacting cell group. The bud, with or without an apical cell, not only develops the stem cylinder but in practically all living species also produces lateral appendages, or leaves, in the axils of which axillary buds may or may not be present. The fundamental, radially symmetrical system is also present in the sporphytes of all Bryophyta, altho they do not develop lateral appendages, except the expanded hypophyses of some mosses which may be regarded as continuous lateral appendages whose growth is also controlled by the inherent radial potentiality of the developing system. In the majority of Bryophyta the gametophyte has also evolved the radial potentiality and its superficial lateral appendages, or scales, are also developed in radially symmetrical spiral systems. The fundamental radial symmetry of the sporophyte may be modified so that the stem develops as an oval, quadrangular, triangular, or even decidedly flattened system, but such forms are secondary developments and the plant still shows the primary cylinder at various stages of its growth. When the sporophyte stem develops leaves they are so determined in their positions that after growth is completed, they form a spiral system of greater or less complexity and of greater or less mathematical regularity.

The spiral system is not only a characteristic of the leaf arrangement, or phyllotaxy, but involves also the structure of the vascular system and other tissues in the stem. The spiral structure is prominently in evidence in the skeletons of old stems of the tree prickly-pear, Opuntia imbricata (Haw.) Engelm., in which the specific spiral system can be determined as readily from the large gaps in the vascular cylinder as from the external leaf positions. The branches of Cercis and Pedilanthus and of many other plants show a zig-zag character in harmony with their alternate two-ranked leaf arrangement. The correspondence between the structural organization of the twig and leaf arrangement is clearly indicated by the five-angled pith and the five ridges on the bark of cottonwood twigs, Populus balsamifera L. The same relation is also prominently shown in young shoots of various species of blackberries, as in Rubus frondosus Bigel., by the five-angled pith and the five very prominent ridges on the

¹ Papers from the Department of Botany, The Ohio State University, No. 403. [The Bulletin for October (65: 433-505) was issued October 1, 1938]

stem. Thus, it is evident that the leaf positions and the structural relations of the stem are primarily determined by the same fundamental potentiality. There is a fundamental potentiality of spiralization which determines the relative positions of the leaf incepts and the correlative interactions of these centers of growth activity in relation to each other and also determines the general arrangement of the tissue systems througut the total mass of cells of the growing bud. The addition of a further potentiality to the hereditary complex which causes the production of internodes does not change the general spiral system but is to be regarded as only a third advance in the progressive complexity of the sporophyte stem along with the fundamental radial symmetry and potentiality for spiralization.

What the ultimate nature of this potentiality of spiralization may be cannot be surmised at present, but it is, nevertheless, something quite as definite as the force of crystallization in the various chemical substances. It is some internal correlative or coordinating interaction force or potentiality which determines the physiological gradients of the bud and the structural positions of the new incepts for leaves or other lateral organs as the growth of the bud proceeds. One thing is certain; the positions in the spiral systems are not primarily dependent on any predetermination of the structural elements of the stem already laid down, since the system may change in any given bud from one type to another. The differentiation of the structural elements is determined by physiological or physico-chemical forces in action at the time of growth. Thus, very profound reaction changes are especially in evidence when a bud changes from an alternate, two-ranked, vegetative system to a reproductive, trimerous or pentamerous system in the flower. Whatever the factors involved may be, the final result is produced by a combination of all the growth forces and growth processes active in the given system.

By controlling the ecological-physiological conditions, the writer was able in the hemp plant, Cannabis sativa L., to cause a change from opposite to alternate leaf arrangement at any level of stem development beyond the few opposite nodes which had already been determined in the plumule of the embryo. After rejuvenation of old plants the alternate leaf arrangement also frequently changes back again to the opposite condition (Schaffner, 1926). The change from one vegetative spiral system to a succession of others during the ontogenetic growth gradient is easily seen in many common plants.

Recently it has become the vogue to attempt to explain all growth reactions on the basis of hormones and growth-promoting substances, but such agents can only be secondary in the determination of spiral systems. The accumulation of hormones may stimulate cell division at certain

points but the real problem is to discover the mechanism which determines the mathematical positions where the substances accumulate, if there is such a relation between growth and the supposed stimulating substance.

There is at present much superficial reasoning about the influence of cosmic rays, violet rays, temperature, etc. as primary causal agents of evolution, but a study of the spiral systems as well as of numerous other biological systems in relation to the general taxonomic system shows that all such reasoning is beside the mark. There is no evident correspondence between the presence of the supposed causal agents and the systems themselves. For example, the grasses, numbering over 4,000 species, with numerous tribes, subtribes, and genera, have been on the earth for an enormous period of geological time and at present extend from the Equator to the Arctic regions, from the water to the desert, from sea level to the vegetation limit of high mountains, yet they all have the alternate, two-ranked spiral system in their vegetative shoots. The sedges are close lower relatives of the grasses and are nearly as widely distributed over the earth, often growing in the same habitats and thus subjected for ages to the same physical agents—heat and cold, violet rays, cosmic rays, etc.—as the grasses, but this has not given them the same spiral system. The vast majority of them have the spiral three-ranked leaf arrangement, frequently with three-angled stems. A few species have their leaves arranged in complex multispirals.

By various authors, as in Schwendener's mechanical hypothesis, the stimulus determining the positions of the incipient leaf members was assumed to be the pressure exerted by the developing leaves covering the growing bud. But such an explanation represents a purely superficial view, since many stems with only minute, vestigial leaves have very definite spiral systems, as in many cacti and spurges.

When one studies various phylogenetic series, it soon becomes evident that in the lower levels of the series there is frequently much variation in the number of spirals produced even on the same stem and between branches of the same plant, and that the control of the spiral development goes thru certain evolutionary sequences, which at the higher levels commonly end in one of a few determinate, stable systems, unless some unusual hereditary factor is introduced, such as a special expansion potentiality active either in the vegetative or reproductive phase or in both. These culminating systems become practically fixed and unchangeable in entire families or even larger groups and are of great importance in determining taxonomic relationships.

Apparently the lower vascular plants had comparatively simple spiral systems, as is the case in the living species, and these became more com-

plex in various lines thru the progressive evolution of larger buds with no corresponding increase in the efficiency of the internal correlative control or coordinating interactions from the centers of activity to the surrounding cells. Thus, the larger the bud the greater the number of spirals produced at any given level, and thus sometimes an enormous difference on stems. branches, or flowers of different sizes, as is prominently shown in nearly all species of Equisetum. With the evolutionary advancement in the efficiency of the correlative control from the determined centers, the vegetative spiral system will be simplified again on the higher evolutionary levels even tho there be a decided increase in the size of the growing bud. Two prominent culmination types become established in many phyletic lines of Pteridophyta, Gymnospermae, Monocotylae, and Dicotylae. The two normal culminations or determinate types are (1), the alternate, tworanked arrangement, in which the center of activity has the largest controlling influence possible in a radially symmetrical system, taking in the entire cross-section at the given growth level; and (2), the opposite, fourranked system which becomes the normal, determinate limit when the pitch of the clockwise and counter-clockwise primary spirals becomes the same, with the centers of activity at each node reduced to the smallest symmetrical number, namely two. Unusual or abnormal, extreme systems are the opposite two-ranked arrangement and the unispiral system. Both of these are very rare. An advanced system may be evolved in the plant which may be expressed only at a certain stage of the ontogeny. Thus, in Cyperus the extreme, two-ranked condition appears only in the branches of the inflorescence. In some species of Helianthus the opposite, fourranked system is developed in the juvenile stage while in the later periods of growth the five-ranked arrangement is expressed. The same is true for the hemp, Cannabis sativa L. Thus it must be recognized that a more recently acquired spiral reaction system may come to expression either in the early juvenile stage or in the later growth stages of the ontogeny.

It is an interesting fact that the growth of true roots rarely if ever shows an indication of a definite spiral control. The root branches seem to develop in a rather haphazard fashion. The potentiality for spiralization seems to be completely latent, altho as soon as a stem bud develops on a root it immediately begins a spiral activity, shown by the spiral arrangement of its lateral organs. In *Stigmaria* fossils, which represent branched stems penetrating the ground like root systems from the base of the tree trunk, the root-like structures have the positions of leaves in spirals and probably have some relation to leaf structures.

Elaborate systems of phyllotaxy have been developed, but these have dealt especially with abstract mathematical and philosophical theories on

the one hand or on the other with fantastic teleological speculations as to the causal relations of the different spiral systems to their environments or to supposed special advantages of one type or another of leaf arrangement to the individual. There was little of practical value in these speculations, and Sachs was inclined to dismiss the subject from serious consideration as "playing with figures." But these rhythmical processes of growth are a very prominent part of the phenomena of life and as such demand study from various points of view. The abstruse and complicated mathematical treatments and speculations could not arouse very much enthusiasm in the non-mathematical botanists, who both in the past and at present constitute nearly the entire taxonomic clan.

The general system of phyllotaxy still in vogue lays especial stress on the angle of divergence, or the proportion of the distance around the stem that one leaf is removed from the one next in age, as in the Fabonacci series but the sequence of the order of appearance may be considerably changed thru various causes and thus cannot be used, except in the simplest systems, as a basis for fundamental mathematical speculations. The ontogenetic gradients may be modified by determinate factors, by zygomorphic or inequilateral factors or by expansion factors at various points of development. In the more primitive type of typical flowers, as in *Lilium* for example, the members appear in acropetal succession. In advanced types the cycles are often practically synchronous in origin. In some, the incepts of the carpels may appear before those of the stamens, or the incepts of the sepals may develop after those of the stamens. In Capsella the petals are the last to appear. In zygomorphic flowers there is often a decided difference in the appearance of the incepts of the members of a single cycle. But these changes in sequence of the ontogenetic development do not change the fundamental nature of the spiral systems involved, and one cannot tell from the matured structures in what sequence the different members originated. From a practical point of view, we are more especially interested in the character of the completed systems and should deal with them as such. Nor are we concerned whether the systems are mathematically exact. They can at best be only approximate. The exact mathematics of any material system is only in the mind of the mathematician. Flattened stems, as in some species of Opuntia, may still show an evident spiral system. Dorsiventral shoots are due to secondary potentialities which are imposed on the more primitive radial systems and the typical cylindrical spirals are thus modified, but such cases do not at all invalidate the spiralization as a fundamental system.

The subject of phyllotaxy also developed a difficult terminology with such terms as divergence angle, orthostiches, parastiches, decussate, genet-

ic spiral, genetic cycle and Fabonacci ratios. The "cycle" is defined as the portion of the genetic spiral between any two leaves directly above one another, a meaning quite different from that in general use when a flower is said to be cyclic, tricyclic, pentacyclic, etc.

The so-called Fabonacci series of fractions, named from its discoverer, is as follows: 1/2, 1/3, 2/5, 3/8, 5/13, 8/21, 13/34, 21/55, etc. It corresponds to a selected list of ratios that can be found in the spiral systems of plants, but, as will appear below, the system as a whole is very much more complex. This Fabonacci series of fractions was in the past even compared with a somewhat similar series of approximate numbers representing the relative distances of the planets from the sun, usually known as "Bode's law."

The teleological explanations given in the past for the various systems of phyllotaxy are, as would be expected, commonly extremely absurd and inconsistent. The Fabonacci relation being the commonest, it was assumed to be possibly the most primitive type. Another especially fantastic notion has been held that the present spiral systems of the vascular plants are the outcome of a long series of progressive adaptations. Bonnet assumed that the spiral arrangements gave the optimum advantage for transpiration, while Wiesner gave an equally fantastic teleological explanation, that the Fabonacci relation gives the optimum angle for maximum exposure to light in photosynthesis. Such teleological explanations are easily laid to rest when one has advanced far enough in taxonomic studies to learn that similar spiral systems are present where the leaves are vestigial or are reduced to minute scales, as in many cacti, milkweeds, spurges, etc., and as in the scale leaves on the ordinary branches of Pinus, the bracts on the cup of the fruit in Quercus, and the scales on the surface of the pericarp of the fruit of some palms as in Raphia and Calamus. As well might one seek to find a teleological explanation for the angles of the various species of crystals of chemical compounds.

A SIMPLE METHOD FOR REPRESENTING SPIRAL SYSTEMS

After many years of taxonomic study and teaching of advanced students, the writer has attempted to develop a simple, definite, and practical method for constructing projection diagrams of all types of spiral systems, whether simple or complex, and also to devise a system of numerical formulae that would indicate the complete and exact nature of the various types and their ordinary modifications. The aim was especially to develop a system that could be used conveniently for both vegetative shoots and flowers. In the present paper the intention is to present the simple facts of the spiral systems so that the more important patterns can be used con-

veniently in systematics and in the discovery of evolutionary trends, sequences, and limits in the various phyletic lines.

All normal types of mature spiral systems, developed on a cylinder, contain four main morphological characteristics: (1) one or more clockwise primary spirals, (2) one or more counter-clockwise primary spirals, (3) two or more ranks, or radii, either straight or spiral, and (4) one or more secondary spirals whenever the clockwise and counter-clockwise primary spirals are unequal in number; or if the primary clockwise and counter-clockwise spirals are equal in number there are no secondary spirals but the leaves or other members are in cycles. Explanations of these terms are given below. Since the various spiral systems all have these four characteristics, they can all be represented by a formula of four numbers with dashes between them. The clockwise primary spirals are always written first; the second number represents the counter-clockwise primary spirals; the third number represents the ranks or radii; and the fourth number represents the secondary spirals or indicates that the system is cyclic. The direction of the spirals is always to be determined in the direction of growth, namely from the bottom of the shoot to the top.

METHOD FOR CONSTRUCTING PROJECTION SPIRAL DIAGRAMS

The procedure for making a projection diagram of a spiral system is as follows: Take, for example, a comparatively simple spiral system as represented in a twig of Populus balsamifera L. (Cottonwood), a young shoot of Rubus frondosus Bigel., a long potato tuber of the "Idaho Baker" type of Solanum tuberosum L., a carpellate cone of Pseudotsuga taxifolia (Lam.) Britt., or a twig of an oak. These all have either two or three clockwise primary spirals and two or three counter-clockwise primary spirals. The Populus or the Rubus will show a prominent 5-angled pith and five ridges on the surface of the stem corresponding to the five vertical ranks of leaves. The numerical formula will thus be 2-3-5-1 or 3-2-5-1. The spiral system that has the clockwise primary spirals smaller in number than the counter-clockwise primary spirals is said to be a right-handed system and one that has the clockwise primary spirals larger in number than the counter-clockwise primary spirals is said to be a left-handed system. Since the vertical ranks curve in the same direction as the smaller number of primary spirals, the "right-handedness" or "left-handedness" of the system can also be determined by observing the spiral direction of the ranks whenever the curvature in these shows distinctly. Clockwise spiral ranks indicate a right-handed system, counter-clockwise spiral ranks indicate a left-handed system. The curvature, or degree of pitch, of the spiral in the ranks usually depends on the size of the ratio of difference

between the clockwise and counter-clockwise primary spirals, unless there is a distinct torsion of the entire system. The ranks, or radii, are always equal to the sum of the clockwise and counter-clockwise primary spirals with one characteristic exception. The secondary spirals are equal to the difference between the clockwise and counter-clockwise primary spirals and will curve in the same direction as the larger number of primary spirals. If the primary spirals are equal in number the difference will, of course, be zero, which indicates, as intimated above, that there are no secondary spirals but that the secondary system, with one exception, is cyclic.

In determining the primary spirals, always take the next higher, often partly overlapping leaf or other organ beyond the first by moving radially and vertically from the first to the second. Care must be taken, especially if internodes are present, that the primary spiral is not confused with a secondary. With a little practice the primary spirals can be determined without difficulty, especially if one uses a string or marks the successive units as the spiral is traced out.

To construct the projection diagram of the given right-handed system, with the formula 2-3-5-1, one proceeds as follows (fig. 1):

Draw a series of circles, suitably spaced, with pencil so that these guiding lines may be erased, if desired, after the diagram is completed. In figure 1 they have been drawn in ink for distinct reproduction. In a complex multispiral system the circles must be close together in order that a sufficient sample of the system may be shown. Next, draw the required number of radii, properly spaced, and correct these to indicate the spiral pitch of the ranks. These need not be measured accurately for ordinary purposes, since the essential nature of the system will be evident from the primary spirals to be drawn. The radii may be numbered with Roman numerals, always in a clockwise direction for the sake of simplicity and uniformity and always beginning with the uppermost one, as shown in figures 1, 10, 14, 15, 16, and 20.

Now to locate the positions of the members making up the spiral system, taking figure 1 as a model, begin with the upper radius, numbered I, and place a dot on the intersection with the first circle on the outside. Beginning with this point, count the circles or intersections on the radius, —1, 2, 3, 4, 5, 1,—placing a dot on the last "1" and so proceed until the available circles have been counted. To locate the positions on the second radius, pass from the top position on the first radius along the outermost circle, in a clockwise direction, to the second radius (II), and count the number of the clockwise spirals on this, namely,—1, 2, 1,—and place a dot on the second 1; then as before, beginning with this position, count the

intersections toward the center,—1, 2, 3, 4, 5, 1,—marking the second "1" and so proceed until the available intersections have been counted. From any dot on this second radius pass to the third radius (III) and as before count,—1, 2, 1,—again marking the second "1." From this position then one can count the fives either toward the center or the circumference until the proper positions are all marked. One proceeds thus until the proper positions are all marked on all the radii. In case one wishes to proceed in a counter-clockwise direction from the starting point one must count the number of the counter-clockwise primary spirals to get the first position on the radius (V), namely—1, 2, 3, 1,—as will be evident by an inspection of figure 1.

After all the positions have been marked, the clockwise and counter-clockwise primary spirals may be drawn thru them. It is best to draw the spirals first with a pencil and then trace them in ink. In order to have a uniform system of graphs, the writer always represents the clockwise primary spirals with continuous lines, the counter-clockwise primary spirals with broken lines, the radii with lines of small dots, and the secondary spirals, not shown in figure 1, with lines of large dots. The clockwise primary spirals may be numbered with Arabic numerals and the counter-clockwise primary spirals with Arabic numerals in parentheses as in figures 1, 10, 16, and 21. Right-handed spiral systems are represented by figures 1, 2, 3, 4, 6, 7, and 15, and left-handed systems by figures 5, 8, and 20. Apparently all spiral systems may develop, by the law of chance, as right-handed or left-handed systems on branches of the same or of different plants.

Projection diagrams of spiral systems may, of course, be constructed without drawing guiding circles by simply drawing the proper radii and measuring off the given positions with a ruler, but this method is more apt to lead to mistakes in determining the proper positions.

SECONDARY SPIRALS AND CYCLES

A study of the spiral systems clearly indicates that no single "genetic spiral" can be used conveniently to analyze the numerous spiral systems developed in the vascular plants, since the secondary spirals can be one up to a large number. After the primary system has been constructed, secondary spirals are often clearly in evidence and they are sometimes easily seen on the plant itself (see figs. 3, 4, 6, 7, and 8, in which the secondaries are represented). The secondary spirals are determined by skipping one rank or radius when passing from one position to the next and as stated above they curve in the direction of the larger number of primary spirals, when proceeding from the circumference to the center,

or in the direction of the smaller number of primaries if one begins in the center. When the numbers of the primary spirals are large and the number of the secondary spirals is small, as one, two, or three, much counting can be saved in constructing the projection diagrams by determining the positions for the secondary spirals after the fundamental positions have been located on a single radius. If there is but one secondary spiral, as in figures 6 and 8, there will be but one-interval difference from one position to the next on the third radius as one proceeds, if there are two secondaries, as in figure 7, there will be a two-interval difference on the third radius, etc. If the system is cyclic the fact will be indicated by the fourth number of the spiral formula being a zero and the ranks will be parallel to the axis of the shoot unless there is a general torsion of the whole system. In the culmination type of the alternate two-ranked system, 1-1-2-0, there is an apparent exception to the rule that a zero in the fourth number indicates a cyclic system, but since such a system has come to unity, the zero may be interpreted as a cycle with but one member which has attained the highest efficiency of the correlative interaction, controlling the entire cross-section of the bud at the given level (fig. 16).

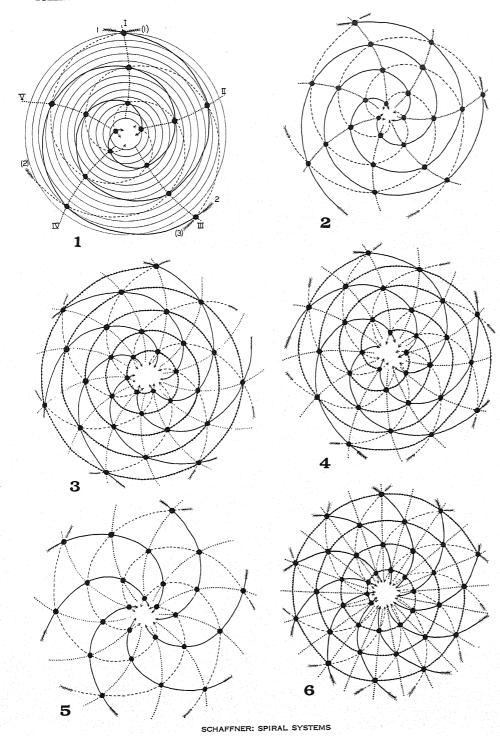
All types of cyclic systems can be represented by the same construction method as is used for the spiral systems with secondary spirals, but a simpler method is available, since by placing the positions alternately at the intersections of successive circles and radii, a similar projection diagram will be obtained. This method has long been used in representing the cyclic-spiral systems as represented by the common cyclic flowers of the Angiospermae. It may also be advantageously used for the diagrams of the cones of Equisetum and for some of the individual cones of Zamia, etc. When one considers the problem as a whole, it becomes evident that the cyclic systems are only special cases of the fundamental spiral system. Typical cyclic systems are represented by figures 11, 13, 19, and 21.

EXAMPLES OF REPRESENTATIVE SPIRAL SYSTEMS

In general, as stated above, the more primitive members of a phylogenetic series have variable spiral systems while advanced groups often have very stable systems, especially if they have attained one of the

Explanation of Plate 22

- Fig. 1. Twig of Populus balsamifera L., spiral system 2-3-5-1.
- Fig. 2. Branch of Lycopodium obscurum L., 3-4-7-1.
- Fig. 3. Carpellate cone of Zamia integrifolia Ait., 6-7-13-1.
- Fig. 4. Carpellate cone of Pinus caribaea Mor., 5-8-13-3.
- Fig. 5. Carpellate cone of Zamia integrifolia Ait., 6-5-11-1.
- Fig. 6. Staminate cone of Araucaria angustifolia (Bert.) O. Ktz., 10-11-21-1.



several determinate culmination types of spiralization. If, however, an expansion hereditary factor has been added to the cell without a corresponding increase in the potentiality determining the control of an area around the incipient center from which a leaf is developed, then the spirals may again be decidedly increased and again show marked variability. Lycopodium lucidulum Mx. is one of the more primitive flowerless types of the living Lepidophyta. Its spiral system is commonly 4-5-9-1 or 5-4-9-1, or 4-4-8-0. Very often all three types are on different branches of the same plant. In the following examples only the formulae for righthanded systems are usually given, but it is to be understood that the corresponding left-handed sytems of any given type are just as common either on the same plant or on different individuals. Lycopodium annotinum L. has the leaves in 4-5-9-1, 4-4-8-0, and 3-4-7-1 spiral systems and the same types for the sporophylls in the cones. In Selaginella arenicola Und. leaf spirals were noted of the formulae 4-4-8-0 and 3-4-7-1, and there are probably others present, while in the cones the sporophylls are reduced to the opposite 4-ranked arrangement, a 2-2-4-0 spiral system. In the numerous higher species of Selaginella both leaves and sporophylls are quite constantly of the opposite four-ranked type. In Equisetum, the lower species are exceedingly variable both in the leaf and sporophyll whorls, the number in a cycle varying with the size of the bud. In the most reduced species, E. scirpoides Mx., all cones and aerial stems constantly have trimerous whorls. The branches of E. pratense Ehrh. also, have trimerous whorls quite regularly. In one of the extreme water-ferns, Azolla caroliniana Willd., the leaf arrangement has attained one of the determinate limits, the alternate two-ranked condition, or 1-1-2-0 spiral system.

In various more advanced lines of vascular plants, the primary bud becomes very large without a corresponding increase in the evolution of the correlative interaction control and in consequence, as intimated above, the complexity of the spiral systems is greatly increased, as in species of Cycas, Palmaceae, Yucca, Fourcroya, Cactaceae, etc. A few stems of Cycas revoluta L. available for study had developed spiral systems as follows: 15-20-35-5, 18-21-39-3, 20-28-48-8, 21-34-55-13, and 34-21-55-13. A stami-

Explanation of Plate 23

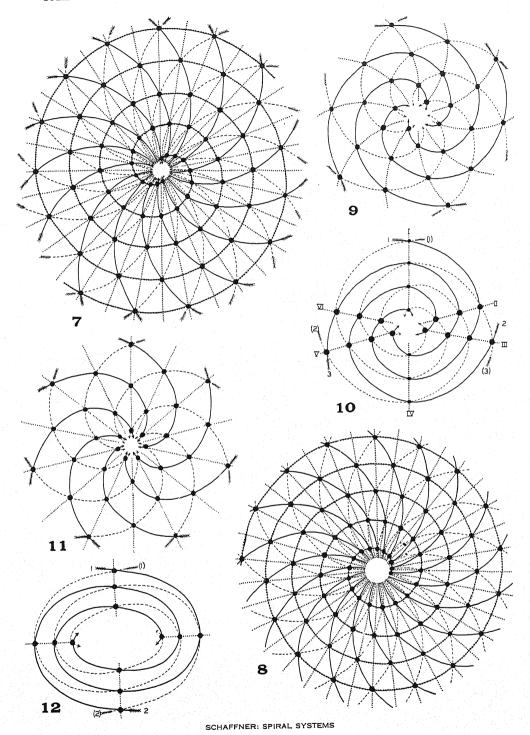
Fig. 7. Staminate cone of Dioon edule Lindl. (1936), spiral system, 15-17-32-2.

Fig. 8. Staminate cone of Dioon edule Lindl. (1937), 18-17-31-1.

Fig. 9. Branch of Opuntia imbricata (Haw.) Engelm., 4-6-10-2.

Fig. 10. Dorsiventral branch of Lycopodium obscurum L., 3-3-6-0. Fig. 11. Staminate cone of Zamia integrifolia Ait., 7-7-14-0.

Fig. 12. Flattened twig of Libocedrus decurrens Torr., 2-2-4-0



nate cone of the same species had the stamens arranged in a 14-17-31-3 spiral system. The staminate cones of Dioon edule Lind. usually vary on the same plant from one blooming season to the next. A staminate plant in the greenhouse had a cone in 1936 with the formula 15-17-32-2 (fig. 7), and in 1937 a cone with the formula 18-17-35-1 (fig. 8). A single carpellate cone available for study gave the formula 8-13-21-5 which corresponds to the Fabonacci fraction 8/21. The new formula shows that the system is right-handed with five secondary spirals while the old Fabonacci fraction does not give this information directly. The flowers of Zamia integrifolia Ait. (Z. floridana DC.) are exceedingly variable and make a very good object for studying spiral systems. The following types of carpellate cones were found: 3-3-6-0, 4-4-8-0, 4-5-9-1, 5-5-10-0, 5-6-11-1, 6-5-11-1, 6-6-12-0, 6-7-13-1. Staminate cones studied gave the following formulae: 4-3-7-1, 5-5-10-0, 6-6-12-0, 6-7-13-1, 7-7-14-0. There are no doubt other types. Any complicated spiral system may for convenience be called a multispiral. A few carpellate cones of Zamia furfuracea Ait. were available for study. These had the following spiral systems: 3-5-8-2, 5-3-8-2, 4-4-8-0, 4-5-9-1, 6-5-11-1. A number of staminate cones of Araucaria angustifolia (Bert). Ktz. showed the following spiral formulae: 10-9-19-1, 10-10-20-0, 11-9-20-2, 10-11-21-1, 11-11-22-0, 11-12-23-1, 12-10-22-2, 12-11-23-1, and 12-12-24-0. The carpellate cones of many pines have the 5-8-13-3 spiral system, among which may be mentioned Pinus caribaea Mor., P. taeda L., P. torreyana Carr., P. sabiniana Dougl., P. coulteri D. Don., P. nigra Arnold, P. virginiana Mill., and P. glabra Walt. Picea abies (L.) Karst. also has carpellate cones with the 5-8-13-3 formula. Staminate cones of Pinus nigra Arnold vary considerably. Study of only a few cones gave the following spiral systems: 7-6-13-1, 7-7-14-0, 8-8-16-0, and 9-8-17-1. Tsuga canadensis (L.) Carr. usually has carpellate cones with a 2-3-5-1 or a 3-2-5-1 spiral arrangement but in a small collection one was found with a 4-3-7-1 system.

The alternate two-ranked spiral system, 1-1-2-0, is present in vegetative shoots of great numbers of the Angiospermae. This system, since it is a culmination reaction type, often shows a remarkable constancy, as in the four thousand species of grasses, most of the 10,000 to 15,000 species of Orchidaceae, the thousand species of the Iris family, most of the Scitaminales and numerous other Monocotylae. Large numbers of families and genera of Dicotylae have also attained this extreme, as for example Asimina, Pedilanthus, Tilia, Cercis, Hamamelis, Ulmus, Celtis, Fagus, Planera, Ostrya, Betula, etc. The opposite four-ranked system, 2-2-4-0, is also evolved in many families and genera. Occasionally this system may pass over in individual branches to a trimerous, cyclic condition, and

perhaps some trimerous genera and species are mutations from this type. Among the families with all or most of the species with opposite fourranked leaves may be mentioned, Selaginellaceae, Juniperaceae, Gnetaceae, Oleaceae, Asclepiadaceae, Gentianaceae, Verbenaceae, Lamiaceae, Aceraceae, Aesculaceae, Hypericaceae, Dipsacaceae, Valerianaceae, Caprifoliaceae, and Caryophyllaceae. An abnormal system, apparently derived from the opposite four-ranked condition, is the opposite two-ranked spiral system, 2-2-2-0, in which the normal relation between the primary spirals and the number of ranks or radii does not hold. Two genera which have this extreme system are Chamaesyce and Tribulus (fig 18). It is interesting to note that in both genera the axillary buds or branches have a definite alternate two-ranked arrangement, only one of each pair of leaf axils producing a functional bud, which is alternate with the bud at the next node. Thus, we have here, in the same plant, both an alternate and an opposite position reaction. Another advanced type, but apparently not a culmination, is the spiral three-ranked condition, 1-2-3-1 spiral system, which is so prominently developed in the screw-palms, or Pandanaceae (fig. 15). This type is also very evident in the common greenhouse umbrella-plant, Cyperus alternifolius L., whose leaves, on a long reproductive scape, form three prominent clockwise or counter-clockwise spiral ranks. A common dicotyl genus with this leaf arrangement is Alnus.

In Pandanus the writer observed a bud sport in which the three-spiral changed suddenly to a straight, alternate two-ranked leaf arrangement and grew thus for five years, when it fell back just as suddenly to the normal, spiral three-ranked condition again (Schaffner 1919 and 1925). In this connection it is interesting to note that the two higher families of the Pandanales, Sparganicceae and Typhaceae, have two-ranked leaves. The spiral ranks of Pandanus and the umbrella-plant are apparently not caused by a twisting of the tissues of the stem axis, but the torsion is due to the fact that of the two sets of primary spirals one is twice the number of the other. In Rhoeo and Musa the torsion of the two ranks apparently is due to a forward movement in the successive leaf positions produced by some factor influencing the interaction control system.

The most extreme and at the same time most puzzling spiral system is the unispiral, either clockwise, 1-0-0-0, or counter-clockwise, 0-1-0-0. Here the system is reduced to the ultimate limit of simplicity and altho the organization of the bud is apparently still radially symmetrical the reaction which produces the positions of the leaves is asymmetrical. A genus in which this type is present is *Costus*, as in *C. speciosus* (Koenig) Sm., belonging to the Zingiberaceae. This family normally has the alternate two-ranked spiral system. This unispiral of *Costus* has given rise to much

discussion and difference of opinion as to its cause. Apparently the condition is dependent on a definite hereditary factor for an inequilateral reaction in the growing bud. In the two highest families of the Scitaminales, Marantaceae and Cannaceae, the flowers, altho structurally radially symmetrical, are inequilateral in the development of their parts. A peculiar unispiral sometimes develops in the shoots of various species of Equisetum. Instead of the normal cyclic sheaths a spiral sheath may suddenly develop and usually after a time disappear just as suddenly, the shoot going back to the normal condition. Sometimes the ridges of one or more internodes above the spiral zone show a spiral twist or torsion (Schaffner 1927). In these cases there is apparently no addition of a new hereditary factor but simply a new reaction of the original heredity complex in the cells.

In the hypogynous Liliaceae, the lowest of the subclass Liliiflorae, one finds the Aloe group which contains a whole series of stages in the evolution of the spiral system from very complex multispirals to the normal determinate limit, the alternate two-ranked leaf arrangement. However, the early juvenile stage usually shows a very simple spiral system, even down to the alternate two-ranked condition, and only later is a more complex type developed. This is, of course, commonly the case in many groups, since it takes some considerable period of growth to develop the largesized buds from which the multispirals develop. The writer has not had the opportunity to study any of the large tree species with complex spiral systems but among the species with complex multispirals are Aloe rubrolutea Schinz., A. speciosa Bak., and A. aethiopica (Schweinf.) Berg. The following species have been studied: Haworthia reinwardtii Haw., spiral formula 3-5-8-2; Aloe arborescens Mill., 2-3-5-1; Kniphofia uvaria (L.) Hook., 2-2-4-0; Aloe variegata L. and A. viscosa (L.) Haw., 1-2-3-1; A. plicatilis (L.) Mill., A. haemanthifolia Mar. and Berg., and A. cooperi Bak., 1-1-2-0; A. ciliaris Haw., 1-1-2T-0. The symbol T indicates a torsion system and that the ranks are definitely spiral where one would usually expect straight ranks.

Explanation of Plate 24

Fig. 13. Dorsiventral branch of Lycopodium complanatum L., spiral system, 2-2-4-0.

Fig. 14. Dorsiventral branch of Selaginella kraussiana A. Br., 2-2-4-0.

Fig. 15. Inflorescence shoot of Cyperus alternifolius L., 1-2-3-1.

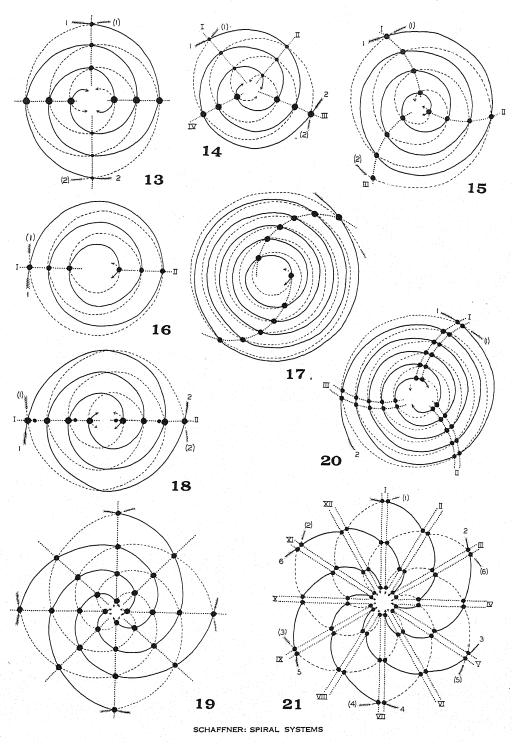
Fig. 16. Twig of Ulmus americana L., 1-1-2-0.

Fig. 17. Stem of Rhoeo discolor Hance, 1-1-2T-0. Fig. 18. Stem of Chamaesyce preslii (Guss.) Arth., 2-2-2-0.

Fig. 19. Branch of Lycopodium lucidulum Mx., 4-4-8-0.

Fig. 20. Sweet corn ear (6-rowed) of Zea mays L., 2-1-3-1.

Fig. 21. Dent corn ear (24-rowed) of Zea mays L., 6-6-12-0.



Variations in the spiral arrangement of the leaves is shown by the twigs of Morus alba L. The main axis, water shoots or vigorous branches may have a 2-3-5-1 arrangement or a 1-2-3-1 system and the more slender lateral twigs normally have the alternate two-ranked arrangement, 1-1-2-0. This condition apparently indicates that the white mulberry has attained the final potentiality of the two-ranked system but in such a weak condition that it is only expressed in the smaller, least vigorous buds. Similar conditions are frequently met in other groups. Thus in the oaks, Quercus, the leaves have the common five-ranked arrangement, 2-3-5-1, while in the chestnut, Castanea dentata (Marsh.) Borkh., the small lateral branches usually have the alternate two-ranked leaf arrangement while the more vigorous main branches have the 2-3-5-1 system. In the related beech, Fagus americana Sweet, the most advanced and specialized of the three genera, the branches usually have only the alternate two-ranked leaf arrangement. The juvenile arrangements do not, however, necessarily indicate the more primitive condition.

A plant which shows very prominently the relation between the primary spiral system and the vertical ranks is the common greenhouse species, *Euphorbia lacta* Haw. Very frequently one can observe among its various, thick, fleshy branches some with three spiral ridges, 1-2-3-1, some with four ridges, 2-2-4-0, and some with five ridges, 2-3-5-1. The primary spirals can easily be determined by twining strings around the stems thru the leaf positions or clusters of spines. The three-ranked joints usually show a decided, spiral twist.

EFFECT OF THE EVOLUTION OF SPECIAL EXPANSION FACTORS

Altho there is a general evolutionary movement in most advanced phylogenetic series toward a reduction and simplification of the spiral system, yet hereditary expansion factors are frequently introduced which may enlarge either the vegetative or reproductive buds and axes very decidedly and may thus cause a great increase in the number of spirals produced in the expanded part. With the introduction of such a factor, the hereditary reaction may again bring out decided fluctuations in the number of spirals produced. This condition is usually prominent in the disk of the common cultivated sunflower, *Helianthus annuus* L., and in the ear of Indian corn, *Zea mays* L. The great increase in the number of spirals in some stems of cacti has apparently also been caused by the evolution of expansion factors along with fleshiness.

The development of a great disk as in the common sunflower brings in a new mathematical problem, since there is a constant increase of the number of spirals on the disk from the center to the margin. In such a case

one can count the clockwise and counter-clockwise primary spirals at the outer part of the disk and simply write these two numbers in the formula. A disk $4\frac{1}{2}$ inches in diameter had 55-86 primary spiral formula; one 11 inches in diameter had 83-122; one 15 inches in diameter had 144-89. It is evident that with a further enlargement of the disk, the number of the spirals could be much greater.

In the Andropogoneae, the spikelets are usually in pairs and thus if one wishes to ascertain the spiral arrangement in an ear of Indian corn, Zea mays L., a pair of grains must be taken for each position. The simplest ear has two double rows of grains and is thus a 1-1-2-0 spiral system. From this rare condition one can find, among the varieties, a continuous series up to the 6-6-12-0 (24-rowed) type and far beyond. The 6-rowed ear, 1-2-3-1 spiral system, is also exceedingly rare (fig. 20). A diagram of a 24-rowed ear is shown in fig. 21. A 14-rowed ear has a 3-4-7-1 or 4-3-7-1 spiral system. The ear often changes from a higher to a lower system at or near the middle. Thus an ear was found having 16 rows in the lower half and 12 in the upper half; another one had 20 rows in the lower half and 18 in the upper half. When the change is abrupt, as it was in these two cases, there is irregularity on the transition zone but the normal double-row, spiral system is soon established again with the reduced numbers.

EXAMPLES FOR A SYSTEMATIC STUDY OF THE SIMPLER SPIRAL SYSTEMS

In the list below only right-handed formulae are given. All those with unequal numbers of clockwise and counter-clockwise primaries will also occur in the left-handed condition.

- I. Examples of complex multispiral systems are represented by Figs. 6, 7, and 8.
- II. Cyclic spiral system 7-7-14-0, a staminate cone of Zamia integrifolia Ait. (fig. 11).
- III. Spiral system 6-7-13-1, a carpellate cone of Zamia integrifolia Ait. (fig. 3).
- IV. Spiral system 5-8-13-3, involucre of artichoke, Cynara scolymus L., inflorescence fruit of the pineapple, Ananas comosus (L.) Merrill, carpellate cone of Pinus caribaea Mor. (fig. 4).
- V. Cyclic spiral system 6-6-12-0, a carpellate cone of Zamia integrifolia Ait., vegetative shoots of Galium triflorum Mx. and G. concinnum T. & G.
- VI. Spiral system 5-6-11-1, a carpellate cone of Zamia integrifolia Ait.
- VII. Cyclic spiral system 5-5-10-0, a staminate cone of Zamia integrifolia Ait., a large stem of Selaginella arenicola Und. This is a pentamerous ten-ranked system.
- VIII. Spiral system 4-6-10-2, a branch of Opuntia imbricata (Haw.) Engelm. (fig. 9).
 - IX. Spiral system 4-5-9-1, branches of Lycopodium lucidulum Mx. and L. annotinum L. and main stem of L. obscurum L.
 - X. Cyclic spiral system 4-4-8-0, some branches of Lycopodium lucidulum Mx., some cones of L. obscurum L., some branches of Equisetum arvense L., some stems of Selaginella arenicola Und., stem of Galium circaezans Mx. This is a tetramerous, eight-ranked system (fig. 19).
- XI. Spiral system 3-5-8-2, carpellate cones of *Pinus strobus* L. and *Sequoia washingtoniana* (Winsl.) Sudw., branch of *Opuntia imbricata* (Haw.) Engelm.
- XII. Spiral system 3-4-7-1, some shoots of Selaginella arenicola Und., some cones of Lycopodium obscurum L., some branches of Opuntia imbricata (Haw.) Engelm. (fig. 2).

- XIII. Cyclic spiral system 3-3-6-0, Equisetum scirpoides Mx., Salvinia natans (L.) Hoffm., Juniperus communis L., some branches of Catalpa speciosa Ward., flowers of Yucca, Lilium, Iris, etc. This is a ternate six-ranked system (fig. 10).
- XIV. Spiral system 2-3-5-1, twigs of Rhus glabra L., young shoots of Asparagus officinalis L., Quercus sp., Populus sp. This is the five-ranked spiral system and is very common (fig. 1).
- XV. Cyclic spiral system 2-2-4-0, the higher species of Selaginella, Thuja, Gnetum, Naias, Acer, Salvia, Bidens, etc. This is the opposite, or dimerous, four-ranked system and is a very common culmination type (figs. 13, 14).
- XVI. Spiral system 1-2-3-1, Pandanus sp., Alnus sp., reproductive shoot of Cyperus alternifolius L. This is the alternate spiral three-ranked system (fig. 15).
- XVII. Cyclic spiral system 2-2-2-0 with the axillary buds and branches in the 1-1-2-0 spiral system, *Chamaesyce* sp., *Tribulus terrestris* L. This is the rare, abnormal, opposite two-ranked system (fig. 18).
- XVIII. Alternate two-ranked torsion system with the two ranks prominently spiral, 1-1-2(T)-0, Cordyline terminalis Kunth, Rhoeo discolor Hance, Musa sapientum L. (fig. 17).
- XIX. Spiral system 1-1-2-0, Azolla, Graminaceae, Iridaceae, Asimina, Tilia, Cercis, Ulmus, Zygocactus truncatus (Haw.) K. Schum. This is the normal alternate two-ranked arrangement with straight or nearly straight ranks and is the normal culmination type of the spiral system in many plant groups (fig. 16).
- XX. Unispiral system, 1-0-0-0 or 0-1-0-0, Costus speciosus (Koenig) Sm. and shoots or zones of shoots of Equisetum sp. This is a very rare abnormal type, showing an inhibition of the fundamental, radially symmetrical reaction system.

SUMMARY STATEMENT OF RELATIONS IN THE SPIRAL SYSTEMS AND METHODS OF CONSTRUCTING FORMULAE AND PROJECTION DIAGRAMS

- 1. All normal spiral systems, developed on a cylinder, have both clockwise and counter-clockwise primary spirals, the direction to be determined in the direction of growth. In constructing projection diagrams of spiral systems the base is always to be represented at the outer part of the circle and the upper part in the center.
- 2. If the number of clockwise primary spirals is smaller than the number of counter-clockwise primaries, the system is said to be right-handed and if the number of clockwise primary spirals is larger than the number of counter-clockwise primaries, the system is said to be left-handed.
- 3. The number of vertical ranks, or radii, is equal to the sum of the clockwise and counter-clockwise primary spirals, except in the rare, opposite two-ranked arrangement which is an abnormal type.
- 4. The vertical ranks, or radii, curve in the same direction as the smaller number of primary spirals. A right- or left-handed system can then also frequently be determined by the spiral direction of its vertical ranks. If the ranks curve in a clockwise direction the system is right-handed, if counter-clockwise, the system is left-handed.
- 5. The secondary spirals are equal in number to the difference between the clockwise and counter-clockwise primary spirals and are determined

by skipping one radius in going from one position to the next on the projection diagram or on the spiral cylinder.

- 6. The secondary spirals curve in the same direction as the larger number of primary spirals in the system.
- 7. If the clockwise and counter-clockwise primary spirals are equal in number, there are no secondary spirals but the parts are in cycles and the ranks, or radii, are straight and parallel to the axis unless there is torsion of the entire system. The cyclic condition is produced whenever the pitch of the clockwise and counter-clockwise spiral screws becomes equal. In the extreme, alternate two-ranked system, the rule that the zero indicates a cyclic system does not hold unless it is assumed that the one member controlling the entire cross-section of the growing bud at the given level makes a cycle.
- 8. Any spiral system can be conveniently represented by a formula of four numbers as, for example, the common, right-handed, five-ranked type by 2-3-5-1, or the opposite four-ranked type by 2-2-4-0. The first number represents the clockwise primary spirals, the second number the counterclockwise primary spirals, the third number the ranks, or radii, and the fourth number the secondary spirals, or if the number is zero a cyclic system without any secondary spirals.
- 9. The two possible, normal evolutionary culmination types are the opposite four-ranked and the alternate two-ranked systems, both of which are very abundant in the higher evolutionary levels of certain phyletic lines.
- 10. The two abnormal culmination types, which form exceptions to the general rules of spiralization are the opposite two-ranked and the unispiral conditions, in both of which there is some exceptional factor which changes the normally, radially symmetrical reaction of the growing stem bud.
- 11. Any spiral type may be distorted by growth torsion or by twisting of the whole system.
- 12. Irregularities in positions may be developed in any system during growth when the reaction changes from one type to another thru the influence of internal or external environmental conditions, especially when the cell system contains factors for more than one type of reaction, as in those plants which have potentialities for both the primary-secondary spiral system and the primary spiral-cyclic system. Certain abnormal developments, as faciation for example, may cause very great disturbances, but these abnormalities have no direct bearing on the problem of the fundamental nature of the spiral systems.

HISTORICAL DEVELOPMENT AND BIBLIOGRAPHY OF SOME RECENT PAPERS

Consideration of the historical development of the theories of phyllotaxy may properly begin with Bonnet, who published a paper on the subject in 1754. Later, in the years 1830-1835, Schimper and Braun elaborated a system of phyllotaxy and their treatment became the common basis for both criticism and further theory. In the meantime, many investigators, both before and after Schimper and Braun, considered the subject, among whom may be mentioned Goethe, the brothers Bravais, Wiesner, Hofmeister, Schwendener, Eichler, C. de Candolle, and Warming.

Below is given a partial list of important references to the literature which has appeared since the beginning of the present century. However, there are many other papers of importance, besides the ones mentioned, which may be studied by those who are interested in the recent treatment of the subject and the theoretical views entertained.

OHIO STATE UNIVERSITY

College of Agriculture Columbus, Ohio

Bibliography

- 1. Church, A. H. 1901. Note on Phyllotaxis. Ann. Bot. 15: 481-490.
- . 1901-1904. On the Relation of Phyllotaxis to Mechanical Laws. I-III. London.
- -. 1920. On the Interpretation of Phenomena of Phyllotaxis. Oxford Univ. Press. Botanical Memoirs. No. 6. pp. 1-58.
- 4. Davis, P. A. 1937. Leaf Arrangement in Ailanthus allissima. Amer. Jour. Bot. 24:401-407.
- 5. Hirmer, M. 1922. Zur Lösung des Problems der Blattstellung. Jena.
- 132-206.
- -. 1934. Neue Untersuchungen auf dem Gebiet der Organstellungen. Ber. Deutsch. Bot. Ges. 52: (26)-(50).
- 8. Imai, Y. 1927. The Right- and Left-handedness of Phyllotaxy. Bot. Mag. Tokyo 41: 592-596.
- 9. Priestly, J. H. and Lorna I. Scott. 1933. Phyllotaxis in the Dicotyledons from the Standpoint of Developmental Anatomy. Biol. Rev. and Biol. Proc. Cambridge Phil. Soc. 8(3): 241-268.
- 10. Schaffner, John H. 1919. A Remarkable Bud Sport of Pandanus. Journ. Hered. 10: 376-378.
- -. 1925. What Happened to the Pandanus Bud Sport? Journ. Hered. 11. -16: 62.
- -. 1926. The change of opposite to alternate phyllotaxy and repeated 12. rejuvenations in hemp by means of changed photoperiodicity. Ecology 7:
- ---. 1927. Spiral Shoots of Equisetum. Amer. Fern Journ. 17: 43-47. 14. Schoute, J. C. 1913. Beiträge zur Blattstellungslehre. I. Die Theorie. Rec. Trav. Bot. Néerl. 10: 153-325.

- 15. . 1914. Beiträge zur Blattstellungslehre. II. Ueber Verästelte Baumfarne und die Verästelung der Pteropsida im Allgemeinen. Rec. Trav. Bot. Néerl. 11: 95-192.
- 16. ———. 1922. On whorled phyllotaxis. I. Growth whorls. Rec. Trav. Bot. Néerl. 19: 184–201.
- 17. ———. 1925. On whorled phyllotaxis. II. Late binding whorls of Peperomia. Rec. Trav. Bot. Néerl. 22: 128-172.
- 18. ———. 1932. Ueber die Caryophyllaceen-Dekussation. Ber. Deutsch. Bot. Ges. 50: 229-236.
- 19. Schüepp, O. 1920. Ueber Form und Darstellung der Wachstumskurven. Ber. Deutsch. Bot. Ges. 38: 193–199.
- 20. . 1921. Zur Theorie der Blattstellung. Ber. Deutsch. Bot. Ges. 39. 249-257.
- 21. . 1923. Konstruktionen zur Blattstellungstheorie. Ber. Deutsch. Bot. Ges. 41: 255-262.
- 22. . 1924. Konstruktionen zur Blattstellungstheorie. Ber. Deutsch. Bot. Ges. 42: 322-330.
- 23. ———. 1928. Untersuchungen und Konstruktionen zur Theorie der einfachen Spiralstellung. Jahrb. Wiss. Bot. 68: 867-886.
- 24. Schwendener, S. 1901. Zur Theorie der Blattstellungen. Sitzungsberichte Akad. Wiss. Berlin 1: 556-569.
- 25. Snow, M. and R. 1931. Experiments on phyllotaxis. I. The Effect of Isolating a Primordium. Philos. Trans. Roy. Soc. London. Ser. B, 221: 1-43.
- 26. . 1933. Experiments on phyllotaxis. II. The Effect of Displacing a Primordium. Philos. Trans. Roy. Soc. London. Ser. B, 222: 353-400.
- 27. ——. 1935. Experiments on phyllotaxis. III. Diagonal splits through decussate apices. Philos. Trans. Roy. Soc. London. Ser. B, 225: 63-94.
- 28. . 1937. Auxin and Leaf Formation. New Phytol. 36: 1-18.
- Winkler, H. 1901. Untersuchungen zur Theorie der Blattstellung. I. Jahrb. Wiss. Bot. 36: 1-79.
- 30. ——. 1903. Untersuchungen zur Theorie der Blattstellung. II. Jahrb. Wiss. Bot. 38: 501-544.
- 31. Zimmermann, Walter. 1933. Die Phylogenie der Angiospermen-Blütenstände.
 Untersuchungen zur Gesamtphylogenie der Angiospermen. I. Beih. Bot.
 Zentralbl. 53A: 95-121.
- 32. . 1935. Die phylogenetische Herkunft der gegenständigen und wirteligen Blattstellung. Jahrb. Wiss. Bot. 81: 239-326.



Structure and Growth of the Shoot Apex in Ginkgo Biloba

Adriance S. Foster (with 12 figures and plates 25 to 27)

INTRODUCTION

Although an extensive literature has developed regarding the morphology and phylogenetic relationship of Ginkgo, cf. bibliography in Sprecher (1907), Seward and Gowan (1900), Chamberlain (1935), no careful investigation seems to have been made of the structure of the shoot apex of this primitive gymnosperm. In the meagre literature devoted to this aspect of Ginkgo, two opposed interpretations have appeared. Strasburger (1872 p. 327) concluded that the growing point is differentiated into three well-defined histogens, viz.: an independent "protoderm," a two-layered periblem and a central plerome. Fankhauser (1882, p. 4) confirmed this interpretation with the qualification that the limits between the periblem and plerome are not always distinct. In contrast, Solms Laubach (1884, p. 154, Plate XVIII, fig. 2) described and figured in surface view, a large apical cell with definite segments, in the shoot apex of the seedling. The observations of Sprecher (1907, p. 15), at least in respect to the embryo, failed to support either of these views. Sprecher found that periclinal divisions occur in the superficial layer (i.e. Strasburger's "protoderm") and that furthermore the periblem and plerome arise from a common group of initials. Unfortunately, Sprecher did not investigate the structure of the growing point of the buds of spur and long shoots of the tree.

The evident need for a thorough study of the organization and growth of the shoot apex of *Ginkgo* prompted the present study. In addition, it was hoped that information on this primitive gymnosperm might throw some light upon the disputed organization of the growing point in the Coniferales¹ and hence might lead to a better understanding of the evolution of the apical meristem in seed plants.

It is a pleasure to express my thanks to my wife for her invaluable assistance in the preparation of the illustrations used in this paper. I am also appreciative of the help given by Dr. Otto Schüepp of Basle with several difficult points of theory. Acknowledgement is made for the grant furnished by the Board of Research of the University of California.

MATERIALS AND METHODS

The material used in the present investigation was obtained from several large microsporangiate trees growing near and on the campus of

¹ For reviews of the literature cf. Koch (1891), Schüepp (1926), Korody (1937).

the University of California, Berkeley. During April, May and early June of 1937 terminal buds of vigorous spur shoots were collected two or three times a week. Additional bud material of both spur and long shoots was secured late in the dormant period as well as during the period of shoot elongation in 1938.

To facilitate the rapid penetration of the formalin-acetic acid-alcohol solution used as a killing and fixing reagent, the outer foliar organs were first removed from the buds and the shoot apices then gently evacuated in the killing fluid. The material was dehydrated, cleared in xylene and embedded in paraffin by the usual technique. Serial longitudinal and transverse sections were cut at a thickness of 6, 7 or 8 microns and stained with tannic acid and iron chloride in conjunction with safranin (cf. Foster, 1934). Since accurate orientation of the shoot apices on the block-carrier of the microtome is impossible, it was necessary to section numerous buds in order to secure a significant number of "median" series. The information presented in this paper is based upon a detailed study of nearly 100 longitudinal and about 50 transverse series.

The drawings in this article were prepared as follows: the sections chosen for illustrations were photographed using a high dry objective. Prints were then made on "mat" paper upon which the desired cell outlines and contents were lightly traced in pencil. The final step consisted in placing the prints in a solution which removed the photographic image, after which the penciled outlines were retraced in ink. Unless otherwise stated, all text figures represent a magnification of $\times 17.5$ diameters. The photomicrographs with the exception of text figs. 1 and 2 were taken under oil immersion and have not been reduced for reproduction.

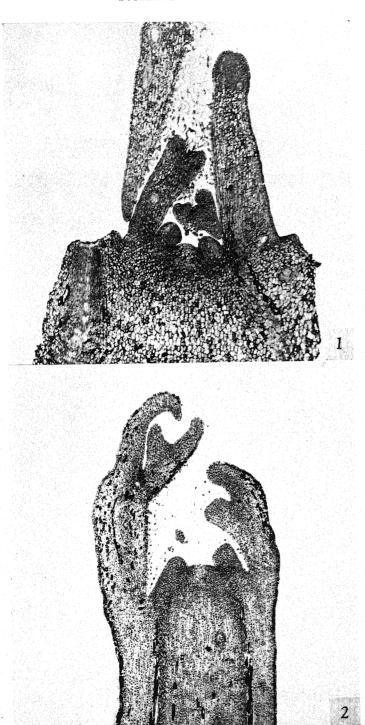
GENERAL MORPHOLOGY AND PERIODICITY OF THE SHOOT SYSTEM

Before describing the structure and growth of the shoot apex, it will be necessary to note briefly certain features of the morphology and periodic development of the vegetative shoot system. As is well known, two well-

Explanation of Figures 1-2

Fig. 1. Median longisection of the upper portion of a spur shoot, April 15, showing the meristematic apex between the two youngest bud-scale primorida. Note the zone of lightly-stained central mother cells, the absence of distinct internodes and the abrupt transition from the rib meristem to the broad expanding pith. ×35. (The detailed structure of the apex of this shoot is shown on Plate 25, fig. 1.)

Fig. 2. Longisection of the upper portion of a long shoot April 18, showing the meristematic apex between the two youngest foliage-leaf primordia. Contrast the prominence of the rib meristem in the future pith and cortical regions and the consequent formation of distinct internodes with the condition in the spur shoot in Fig. 1. Two secretory cavities are seen developing in the central region of the rib meristem. ×35. (The detailed structure of the apex of this shoot is shown on Plate 27, fig. 1.)



Figures 1-2

defined types of shoots occur in Ginkgo, viz.: long shoots, characterized by elongated internodes and relatively small pith and cortex and spur or dwarf shoots, with much abbreviated internodes and comparatively large pith and cortical regions. Observation shows however that these two types of shoots are not morphologically "fixed" in character since the terminal bud of a spur shoot may give rise to a long shoot, and conversely the apical bud of a long shoot may fail to form extended internodes, thereby producing a dwarf shoot (cf. Doak 1935 p. 46, fig. 24). Examination of the trees used in this study indicated that while the "lateral" spur shoots may exhibit a similar growth rhythm for many successive years, a "terminal" spur shoot is very often followed the next season by a true long shoot. The physiological aspects of the mutability and periodicity of spur and long shoots in Ginkgo clearly deserve investigation.

From an histogenetic standpoint, it is significant that no fundamental difference has been found in the cellular organization of the growing points in the two types of shoots. As is shown clearly in Figures 1 and 2, the differences seem to lie basically in the relative extent of and duration of activity in the rib meristem of cortex and pith regions. In the spur shoot, the vertical extent of the rib meristem is short and is followed abruptly by the region of expanding and maturing parenchyma; internodal elongation consequently is at a minimum. In contrast, the production of a long shoot is always associated with a prolonged period of cell division and cell elongation in the rib meristem and the inevitable formation of well-defined internodes.

As is true of many gymnosperms (Koch 1891, Korody 1937) shoot development in Ginkgo involves the annual formation of a series of cataphylls followed by the production of foliage leaves. However, unlike the situation in Abies described by Korody (1937 p. 29) there is little appreciable difference in the relative size or shape of the growing point in Ginkgo during the scale and foliage-leaf forming periods (figs. 1 and 2). Although no attempt has been made in this study to contrast the developmental history of cataphyll and foliage leaf, a brief description will be given later of the early phases in the initiation of these organs.

THE ZONAL STRUCTURE OF THE SHOOT APEX

The most distinctive feature of the meristem of the shoot apex² of Ginkgo is the segregation of its cells into a number of well-defined zones. Fig. 3 represents an effort to depict schematically the position and direc-

² Throughout the present paper, the entire apical region of a bud will be designated as the "shoot apex." The more restricted term "growing point" has such a vague and ambiguous connotation that its use will be avoided as far as possible.

tions of growth of the cells in each zone. Without doubt, Zone II is the most distinctive and unique structural region of the growing point. When viewed in median longisection, this zone appears as a prominent cupshaped group of large, polygonal, lightly-stained cells which are situated in the upper median region of the shoot apex (cf. Plates 25 and 27). From a careful observation of many "median" series it is evident that cell enlargement, rather than cell division is the dominant process characteristic of Zone II. As a consequence, this zone always remains clearly demarcated from the remaining tissue of the growing point, which is composed of much smaller and more frequently dividing cells. The region of transition

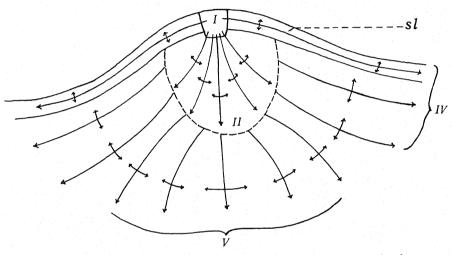


Fig. 3. Diagram illustrating the zones and their mode of growth in the shoot apex of Ginkgo. Zone I represents the position of the apical initial group, from which by anticlinal and periclinal divisions respectively the surface layer (sl) and the internal tissue of the growing point originate. Zone II is the prominent cup-shaped mass of large, slowly dividing central mother cells. As indicated by the arrows, volume growth predominates in this zone. The lateral and basal margins of the group of central mother cells (indicated by the broken U-shaped outline) constitute Zone III, characterized by the smaller size and frequency of division of its cells. From this "transition" zone arise the peripheral subsurface layers (Zone IV) and the rib meristem (Zone V). The long arrows in the surface layer and in Zones IV and V indicate the prevailing directions of growth in respect to the surface of the growing point. In the surface layer and in Zones II, IV, and V, the small double arrows represent the relative amount of growth at right angles to the prevailing direction.

from Zone II to Zones IV and V, as seen in longitudinal view, consists of a U-shaped zone of small, tabular cells; from the latter radiate the densely cytoplasmic inner peripheral layers (Zone IV) and the filamentous cell groups of the rib meristem (Zone V). In transverse sectional view, the

U-shaped "zone of transition" appears as a cylinder of cambial-like cells which entirely surround the cells of Zone II (Plate 26, figs. 1, 2). Since Zone II clearly functions as the common point of propagation of most of the internal tissue of the growing point, its component cells will be termed "central mother cells." Nevertheless, it must be emphasized that the ultimate source of all cells in the shoot apex of Ginkgo is represented by the apical initial group (Zone I, fig. 3; figs. 4, 5, 6c, 7a, 11, 12). These surface cells occupy the median apical region of the growing point and by means of anticlinal and periclinal divisions add new cells respectively to the surface layer (sl in all text figures) and to the central mother cells. However, as will be shown later, the behavior of the cells of the apical initial group seems entirely subordinated to the growth of the shoot apex as a whole and in no sense is comparable to the orderly and precise segmentation typical of certain vascular cryptogams. With this general account of the organization and growth of the shoot apex of Ginkgo, a more detailed description can be given now of the various zones.

APICAL INITIAL GROUP (Zone I, fig. 3)

At the outset, it may be stated that no evidence has been found of the existence of a single permanent apical cell. The presence of such a cell in the shoot apex of the seedling, as described by Solms-Laubach (1884) seems very questionable, particularly since his observations were confined to a surface view of the growing point. Furthermore Lyon (1904 p. 278) in his careful embryological study of *Ginkgo* emphasized that shoot and root growing points "arise through a localization of growth activity out of one general meristematic tissue; and hence from the first are many-celled meristems."

Because of the broad and only slightly elevated form of the growing point, perfect transverse sections of the surface were only rarely obtained in the present study. Figure 4 represents an approximately transverse section through the surface layer and shows a central group of four prominent cells which doubtless represent initials. It is obvious from this preparation, as well as from serial longisections, however, that no regular plan of segmentation exists. New anticlinal and periclinal division walls are inserted at varying angles and frequencies and only rarely is it possible to trace a whole series of surface or internal cells to the repeated division of any of the initials. In other words the geometrical apex of the shoot is occupied by a group of cells, variable in number, from which all the remaining tissue originates. Using Schüepp's (1926 p. 45) terminology, these initiating cells will be designated collectively as the "apical initial group." In their general mode of growth and variable sequence of cleavage, the

cells of the apical initial group in *Ginkgo* are fundamentally similar to the single tier of initials characteristic of *Abies*, *Picea* and *Pinus* (Korody 1937) and of various species of *Lycopodium* (Härtel 1938).

A comparison of serial longisections through many shoot apices in Ginkgo demonstrates that while anticlinal, periclinal and periclinal-oblique divisions occur in the apical initial group, there is no regular sequence in these planes of cleavage. According to the recent investigations of Härtel (1938), anticlinal divisions predominate over periclinal divisions in the apical initial group in the shoot apex of Lycopodium. Whether a similar condition occurs in Ginkgo is not apparent from the present study. It is conceivable however, that significant differences in respect to the relative

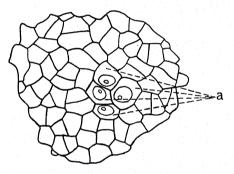


Fig. 4. Surface view of the apex of a spur shoot showing a central group of apical initials (a) and the irregular arrangement of the surface cells derived from them.

frequency of periclinal and anticlinal divisions might be detected in a statistical comparison of long and spur shoots. Some preparations of spur shoots indicate that anticlinal divisions have dominated for a time resulting in the propagation of a regular series of surface cells (figs. 8, 9, 10). Very frequently however, one or more cells in the apical initial group enlarge in an anticlinal direction and then divide by strictly periclinal or periclinal-oblique walls (figs. 5, 6a, 7a, 11, 12; Plate 25, fig. 2; Plate 27, fig. 2). The behavior of the daughter cells resulting from such divisions is highly variable. Often, each cell divides anticlinally resulting in a group of four cells, the outer two of which continue to function as initials while the inner two become incorporated in the zone of central mother cells (fig. 7a). In some instances, this "decussate" type of division may occur in several adjacent cells. Figure 11 for example reveals the products of a trio of unusually prominent apical initials, the laterals of which have divided in a decussate manner while the median cell pair is preparing for the anticlinal division. In other preparations however, the interpretation of the cell net in the apical initial group is complicated by (1) the irregular sequence of anticlinal and periclinal divisions and (2) the wall-bending and enlargement of the inner segments (figs. 6b, 6c, 12). Similar difficulties have been encountered by Härtel (1938 p. 141, figs. 16–19) in the shoot apex of *Lycopodium*.

Lastly it must be noted that, as is true of many conifers (Koch 1891, Korody 1937) and *Lycopodium* (Härtel 1938), periclinal divisions are not confined to the apical initial group in *Ginkgo* but may occur at any point in the surface layer (figs. 6c, 6d, 7b, 10; Plate 25, figs. 1, 2; Plate

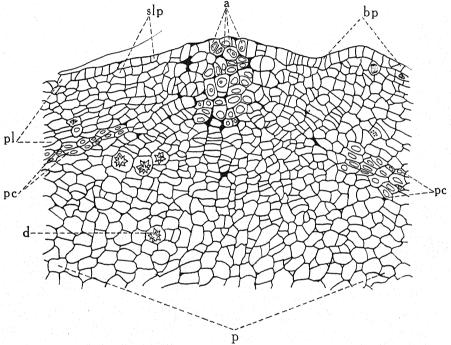


Fig. 5. Median longisection of the tip of a spur shoot, illustrating the typical segregation of the meristem into well-defined zones. ×161. In this and all following figures, the extent of the zone of central mother cells is represented by the large nucleated cells and localized "wall-thickenings" are shown by heavy black outlines.

Legend for all figures: a, cells of the apical initial group; bp, primordium of bud scale; d, druse; p, pith; pc, procambium, pl, zone of peripheral layers; r, zone of rib meristem; slp, periclinal division of surface layer.

27, figs. 1, 2). Consequently, as represented by the small double arrows in Figure 3, the surface layer cannot be regarded as a "dermatogen" (Hanstein 1868) or "protoderm" (Strasburger 1872, footnote p. 325) but on the contrary represents the point of origin of a variable portion of Zone IV. From a cytological standpoint, it is interesting to note that in contrast to the slightly larger and more lightly-stained cells of the apical initial group, the surface cells on the flanks of the apex are smaller and stain

more deeply with safranin (Plate 25, figs. 1, 2; Plate 27, figs. 1, 2). In this respect, they are identical with the cells of the inner peripheral layers and hence are regarded as an integral part of Zone IV (cf. fig. 3).

CENTRAL MOTHER CELLS (Zone II, fig. 3)

In spite of their position in the upper central region of the shoot apex, the central mother cells have none of the characteristics usually associated with the primordial meristem of seed plants (Priestley 1928, 1929). In the first place, they are the largest cells of the apical meristem, often reaching a maximum length of 30-35 microns and a width of 15-20 microns; the cells of the peripheral layers and of the "transition zone" in contrast average $\frac{1}{2}$ to $\frac{1}{3}$ these dimensions. The "enucleated" appearance of certain of the central mother cells shown in Plate 26, figs. 1 and 2 illustrates how, in such large cells, the plane of a thin section may be above or below the level of the nucleus. Secondly, the central mother cells are sharply demarcated from the neighboring peripheral layers (Zone IV) by their larger, more lightly stained nuclei and by the less dense and more vacuolated appearance of their cytoplasm (Plates 25–27). Indeed, from a purely cytological standpoint, the zone of central mother cells bears a marked resemblance to the young apical-cell segments typical of certain vascular cryptogams (Kaplan 1937 p. 229, Zirkle 1932 p. 32). Admittedly, however, the present study is limited to a description of appearances obtained when meristem is killed and fixed in formalin-acetic acid-alcohol and stained in safranin. A further study of the whole problem therefore with the use of a wide range of killing reagents (Zirkle 1932) and stains (Vidal 1912), would certainly be profitable.

Although mitoses have been observed in the central mother cells (figs. 7b, 8, 9; Plate 26, fig. 1; Plate 27, fig. 2) they are noticeably less frequent than is true of the cells of Zones IV and V. Furthermore, indirect evidence of the reduced mitotic activity of the central mother cells is furnished by their relatively large size and by the lightly stained appearance of their nuclei. These facts suggest that, unlike the situation in the primordial meristem of angiosperms, cell enlargement rather than cell division is the dominant aspect of growth in the central mother cells.

As indicated by the highly irregular arrangement of cells, growth in volume is typical of the zone of central mother cells, which thus agrees, at least in this respect, with the corpus region of the angiospermous growing point.³ A careful examination of longitudinal and transverse series shows that no regular plan of segmentation is followed by the central

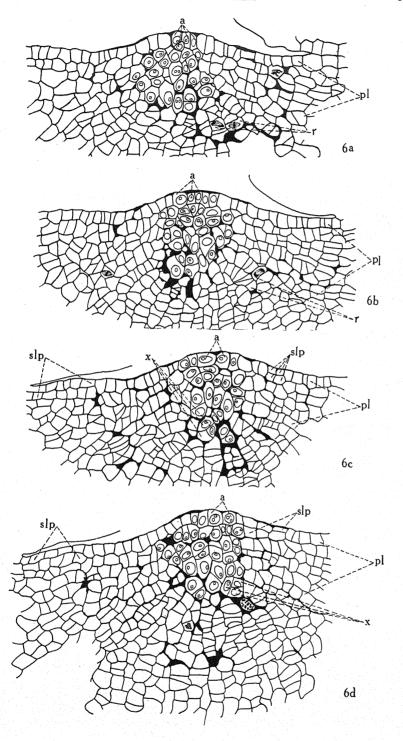
For details regarding the tunica-corpus zones of the shoot apex in angiosperms cf. Schmidt (1924), Priestley (1928, 1929), Foster (1935, 1936, 1937), Cross (1936, 1937, 1938), Newman (1936), Kliem (1937).

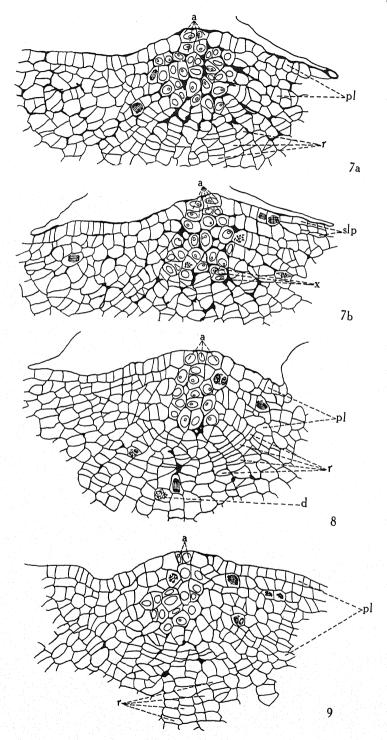
mother cells. Nevertheless, there is a marked tendency for the cells, especially in the "axial" region, to divide periclinally in respect to the surface of the shoot apex (figs. 6b, 6c, 6d, 8, 9, 12; Plate 25, fig. 1; Plate 27, figs. 1, 2). Following such divisions, either or both of the daughter cells may divide anticlinally (figs. 6c, 6d, 7a, 10, 11; Plate 27, figs. 1, 2). In this way, new cells are continually formed toward the peripheral and basal regions of the zone. However, the wall-bending and unequal enlargement of all cells, as well as frequent obliquities in the insertion of new walls are facts which preclude any exact determination of cell lineages. Consequently, it seems reasonable to conclude that fluctuations in the rate and directions of growth within the "plastic" mass of central mother cells determine the cell pattern at any given point, rather than any inherent sequence of cleavages.

A very puzzling but constant feature of the central mother cells is the irregular and often massive "thickenings" which appear at the corners or along the sides of many of the cells (figs. 5-12; Plates 25-27). Although a detailed physical-chemical investigation has not been made, these "thickenings" seem to represent localized deposits of intercellular substance together with unusually thickened areas in the primary wall.4 As is shown in figs. 6d, 7a, 7b, 11, and 12, these depositions frequently resemble very strikingly the "corner thickenings" typical of many collenchyma cells. Occasionally, in longitudinal sections, a surface view is obtained of the entire lateral wall of a central mother cell. From this aspect, the wall thickening appears as an irregular reticulum the meshes of which closely resemble simple pits (Plate 25, fig. 2). It is significant that thickened areas, apparently identical to those in the central mother cells, occur sporadically in other zones of the shoot apex, and serve to delimit cell groups of common origin. This is very obvious at the points of origin of the rib meristem from the base of the transition zone (figs. 6a, 6c, 6d, 7a, 7b, 12; Plates 25, 27).

⁴ The terms "intercellular substance" and "primary wall" are used in the sense recently defined by Kerr and Bailey (1934).

Figs. 6a-6d. Successive longisections, at intervals of 14 microns, through the apex of a spur shoot, illustrating the prominence and clear demarcation of the zone of central mother cells and the origin, mode of growth and planes of division of the cells of the peripheral layers and the rib meristem in various regions of the apex. Fig. 6c is approximately median. Note especially the periclinal divisions which have occurred at various points in the surface layer and the characteristically irregular arrangement of the central mother cells. T divisions, associated with the origin of the rib meristem, are shown in the cell groups labeled X in figs. 6c and 6d.





The gradual disappearance of the "thickenings" in the distal regions of the shoot apex suggests that they may experience "reversible" changes during tissue differentiation.

THE PERIPHERAL LAYERS (Zone IV, fig. 3)

The expression "peripheral layers" designates a well-defined zone composed of several layers of small, densely cytoplasmic cells. A comparison of transverse and median longisections demonstrates that this zone occupies the flanks of the shoot apex and hence completely surrounds the central mother cells (Plate 26, figs. 1, 2). It should be evident, therefore, that in longisections which pass through the sides, rather than the center of the growing point, a definitely stratified arrangement of cells would be seen. Fankhauser's (1884, taf. II, figs. 7–8) failure to observe the zone of central mother cells and his depiction of "periblem" layers would thus appear to depend upon a study of sections cut in this plane. A similar criticism of the statements of Strasburger (1872) in regard to "histogens" in *Ginkgo* seems justifiable.

From a cytological standpoint, all the cells of the peripheral layers are similar in appearance and, in respect to their small size, deeply stained protoplasts and frequent divisions, correspond to typical primordial meristem. This marked uniformity in structure is interesting in view of the difference in point of origin of the various layers. The outermost or truly surface layer, as I have shown, arises from the apical initial group but by sporadic periclinal divisions undoubtedly augments the subsurface layer (figs. 6c, 6d, 7b, 10; Plate 25, fig. 2). In contrast, the inner cell layers have a separate and independent origin. As is shown in Plates 25 and 27, these layers are continually augmented by the division of the cells at the upper periphery of the zone of central mother cells. In terms of cell activity, this peripheral region truly represents a transition zone between an area of cell enlargement (i.e. the zone of central mother cells) and a region characterized by pronounced meristematic features. From this point of view,

Figs. 7a-7b. Longisections through the apex of a spur shoot; Fig. 7a approximately median, Fig. 7b 35 microns distal to Fig. 7a. Both figures illustrate the origin of new central method cells from the inner derivatives of the apical initial group. Note in Fig. 7a the clear demarcation of the U-shaped "transition zone" and in Fig. 7b, a typical T division at X.

Fig. 8. Median longisection through the apex of a spur shoot. Note the anticlinal telophase in one of the central mother cells and the clear definition of the U-shaped transition zone.

Fig. 9. Median longisection through the apex of a spur shoot, illustrating, at the right, anticlinal divisions in several cells of the peripheral layers. Note the polar view of chromosomes in one of the central mother cells.

the central mother cells in *Ginkgo* resemble the situation in the apical meristem of many cryptogams where a zone of large initials merges abruptly into a zone of smaller, dividing cells (cf. Schüepp 1926 p. 6–7). Although it is evident that the sequences of division are variable in the transition zone, transverse sections show that the most recently formed cells are arranged in short radial rows which collectively simulate a cambium (Plate 26, figs. 1, 2). This definitely indicates that the new walls tend to be anticlinal or anticlinal-oblique with reference to the flanks of the shoot apex (figs. 5, 6b, 7a, 8, 11, 12, Plates 25, 27).

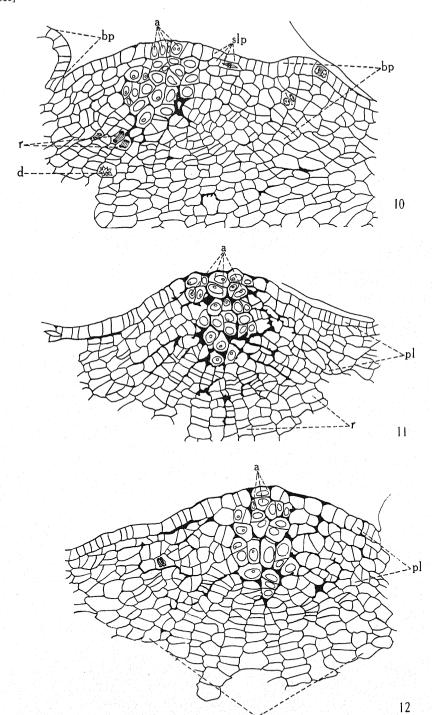
Although surface growth is dominant in the zone of peripheral layers (cf. figs. 3, 8, 9) many irregularities in the cell net are produced by periclinal or oblique divisions. Consequently, the peripheral layers show none of the regularity of growth and independence characteristic of the tunica region of the shoot tip in angiosperms (Schmidt 1924). Their closest resemblance is clearly with the outer meristematic layers found in the shoot apices of conifers (Koch 1891, Korody 1937) and certain species of *Lycopodium* (Härtel 1938). Furthermore, as in the forms just named, the regularity of the peripheral layers is noticeably disturbed by the initiation of bud scales and foliage leaves. The inception of these organs is always associated with a local increase in the frequency of periclinal divisions (figs. 5, 10). Frequently, although not invariably, foliar initiation involves the periclinal divisions of the surface layer itself (fig. 5).

In terms of differentiation, the outer surface layer produces the epidermal system of the shoot while the cortex arises from the inner peripheral layers. Vascular differentiation has not been followed in this investigation but there is evidence that the meristem ring (Barthelmess 1935 p. 214 fig. 5) and hence ultimately the procambium, originates from the innermost layer or layers of Zone IV (cf. fig. 5).

Fig. 10. Median longisection through the apex of a spur shoot, illustrating at the right the origin of a bud scale primordium from the zone of peripheral layers. The presence of a druse in a cell of the rib meristem at the left is indicative of the abrupt differentiation of the broad pith characteristic of spur shoots.

Fig. 11. Median longisection through the apex of a spur shoot, showing an exceptionally prominent trio of apical initials, from which by anticlinal and periclinal divisions, new surface and internal segments have arisen.

Fig. 12. Median longisection through the apex of a spur shoot, showing clearly the irregular size, shape and mode of segmentation typical of the central mother cells. Note the well defined position of the transition zone in this preparation and the clear rib meristem.



THE RIB MERISTEM (Zone V, fig. 3)

The term "rib meristem" has been devised by Schüepp (1926 pp. 18-19) to designate a type of primary meristem which is responsible for the growth in length of young internodes, roots, and the petioles of leaves. Growth in a longitudinal direction prevails in the rib meristem and this tissue consists of vertical series of genetically-related cells which have been formed by repeated transverse (i.e. anticlinal) divisions. Although the entire pith region of a shoot axis is produced by rib meristem, interesting differences exist in regard to the point of origin of this meristem in seed plants. In the dicotyledons, the rib meristem forming the pith originates some distance from the surface of the growing point by the active division of the cells of the corpus (Foster 1935, Cross 1936, 1937). In many conifers however, the pith of the shoot axis differentiates far in advance of the other primary tissues and the rib meristem appears as a central core of vacuolating cells which arises directly from the inner embryonic layers of the growing point⁵ (Koch 1891, Korody 1937). Obviously in both types, the origin of the rib meristem is associated with a more or less abrupt transition from highly meristematic to vacuolating and "stretching" tissue. In Ginkgo just the reverse condition occurs since here the transition to rib meristem first involves the renewal of mitotic activity in the lower central mother cells. As is true of the origin of the inner peripheral layers, this renewed mitotic activity is accompanied by a decrease in cell size and a greater retention of the nuclear stain (Plates 25, 27).

⁵ This fact has been confirmed by the writer in a brief unpublished study of the shoot apex of *Abies venusta*. (Dougl.) K. Koch.

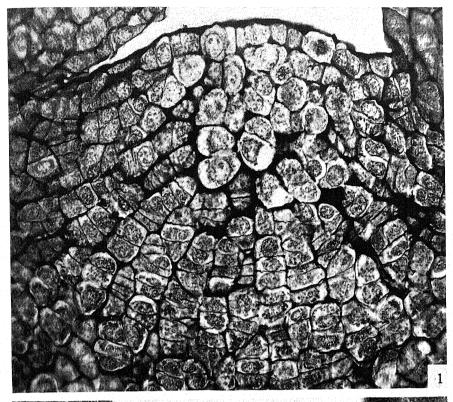
Explanation of plates

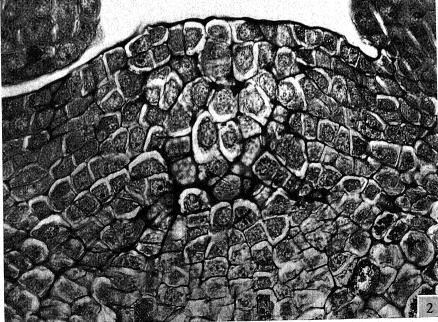
(all figures ×435)

PLATE 25

Fig. 1. Median longisection illustrating the zonal structure typical of the apex of a spur shoot (April 15). The zone of central mother cells, seen in the upper center directly beneath the apical initials, is sharply demarcated from the peripheral layers and the basal zone of rib meristem by the large size, irregular arrangement and lighter-stained appearance of its cells. Note the prominent "wall-thickenings" (stained black) both in the zone of central mother cells as well as in the surrounding zones. An anticlinal metaphase is evident in a cell of the surface layer at the right. The short vertical extent of the rib meristem in this shoot is shown at lower magnification in Text Fig. 1.

Fig. 2. A similar longisection of a spur shoot (April 29). Note especially that the surface layer, on both flanks of the apex, has divided periclinally. To the left and slightly above the prominent metaphase in a cell of the rib meristem, will be seen in surface view the "reticulate" or "pitted" character of the lateral wall of a central mother cell. Note, as in Fig. 1, the rapid maturation of the pith from the short zone of rib meristem.





FOSTER: GINKGO

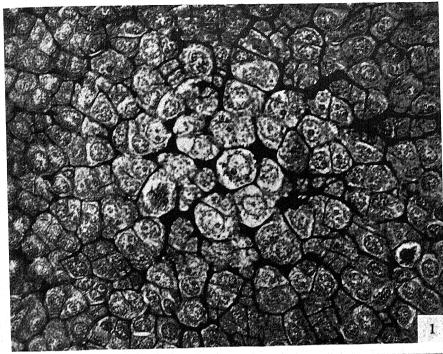
As seen in median longisection, the transition zone giving rise to the young rib meristem appears as a concave area of small, tabular frequently-dividing cells (cf. especially figs. 5, 6b, 7a, 8, 10, 11, 12 and Plates 25 and 27). The well demarcated appearance of this formative region is the result of the early prevalence of periclinal or periclinal-oblique divisions. Frequently, the repeated formation of periclinal walls in several adjacent cells produces regular short filaments of genetically-related cells (figs. 5, 7a, 10). Often however, following the first periclinal or oblique division, the lower daughter cell divides anticlinally thus giving rise to a double series of cells. Such T divisions are illustrated in Figs. 6c, 6d, and 7b by the label X. As noted previously, the wall thickenings of the central mother cells may be "carried over" into the zone of rib meristem and thus aid in the identification of cell groups of common lineage (figs. 6a-6d, 7a-7b, 10, 11, 12; Plates 25, 27).

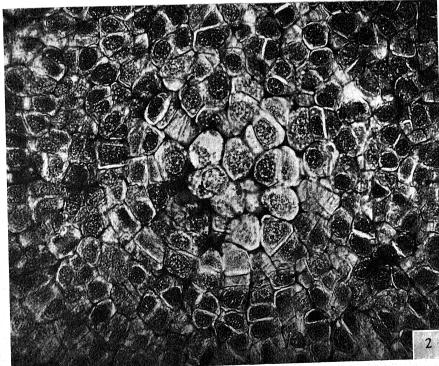
Although the prevailing direction of growth in the young rib meristem is periclinal in respect to the surface of the shoot axis, irregularities in the cell pattern are common and result from periclinal or oblique division of cells at various points. In this way, new chains of cells are formed which appear to "insert" themselves (possibly by "gliding growth") between their neighbors (figs. 6b, 6c, 6d, 7a, 12; Plate 25, fig. 1; Plate 27, fig. 2). A marked difference, which has already been noted, occurs in respect to the duration and mode of growth of the rib meristem in long and spur shoots. In the latter, the rib meristem looses its embryonic character a short distance from the zone of central mother cells and abruptly differentiates into the broad, radially-expanding pith region (fig. 1). Associated with this early cessation of growth, druses frequently appear in many of the cells of the maturing rib meristem (figs. 5, 8, 10). In long shoots however, the rib meristem retains its capacity for growth and cell division for a much longer period of time, and together with the equally active rib meristem beneath the epidermis, makes possible the formation of elongated internodes (fig. 2;

Explanation of Plate 26

Fig. 1. Transverse section of the apex of a spur shoot (April 15) 63 microns below the apical initial group, showing that the large central mother cells (note metaphase) are completely surrounded by the smaller more densely-stained cells of the peripheral layers. The cells of the transition zone, at the margin of the central mother cells, are arranged in irregular radial rows. Compare with Plate 25, figs. 1 and 2.

Fig. 2. Transverse section of the apex of a spur shoot (May 11), 63 microns below the apical initial group depicted in text figure 4. The prominent lightly-stained central mother cells are surrounded by a "cambial-like" transition zone showing a marked radial alignment of cells. Note the anticlinal telophase in one of the cells at the right, and the mitosis in a cell of the peripheral layer at the lower left.





FOSTER: GINKGO

Plate 27, figs. 1, 2). Indeed the unusually active rib meristem in the long shoots of *Ginkgo* would provide excellent material for a study of the rhythmical aspects of mitosis along the lines suggested by the recent investigations of Wagner (1930, 1937).

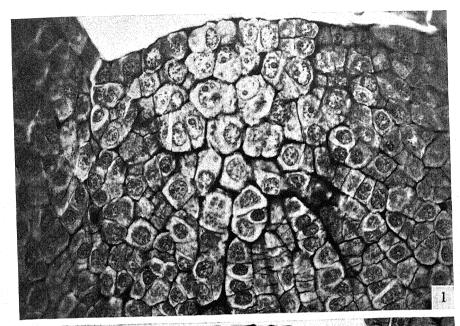
DISCUSSION

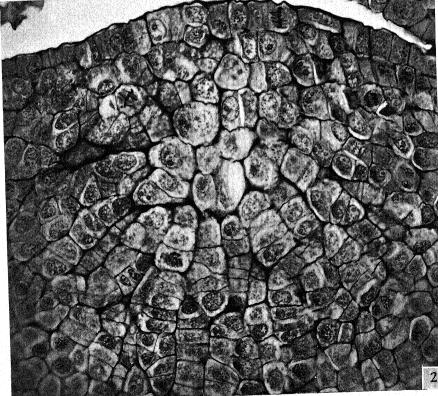
From a comparative anatomical standpoint, the shoot apex of Gingko exhibits a type of structure which, in the light of present knowledge, appears unique among vascular plants. On the one hand, it diverges from such vascular cryptogams as Equisetum (Vidal 1912) and the leptosporangiate ferns (Bower 1889) in the absence of a definite apical cell and the highly variable sequence of cleavages throughout the meristem. The peculiar cytological features of the apical initials and the central mother cells in Ginkgo are, it is true, suggestive of the condition described by Hof (1898) for the apical region of the root of Pteris, and for the shoot tip of Osmunda (Zirkle 1932, pp. 32-36) but the resemblances are clearly "physiological" rather than "morphological." Furthermore, although such plants as Lycopodium (Schüepp 1926 pp. 48-49, Härtel 1938) and the Marratiaceous genera Danaea and Kaulfussia (West 1917) agree with Ginkgo in the possession of a single tier of apical initials, they differ markedly in the zonal arrangement of their meristems. On the other hand, Ginkgo shows but few points of histological similarity with the shoot apices of other gymnosperms. Possibly the closest comparison can be drawn with the Abietaceae which resemble Ginkgo in the form and behavior of the apical initials and especially in the absence of a typical "dermatogen" (Koch 1891, Korody

Explanation of Plate 27

Fig. 1. Longisection showing the details of structure of the apex of the long shoot illustrated in text figure 2. Note the marked contrast between the large, lightly-stained central mother cells (upper center of figure) and the smaller cells of the peripheral layers and the rib meristem. At the right of the apical initial group will be seen a quartet of cells produced by the "decussate" division of a surface segment. As in the apices of spur shoots (Plates 25 and 26) irregular "wall thickenings" are evident in the zone of central mother cells and help to define genetically-related cell groups in the rib meristem.

Fig. 2. Longisection illustrating the characteristic structure, mode of growth and planes of cell division in the various zones of the apex of a long shoot (April 22). Note the recent periclinal division in a cell of the apical initial group and the anticlinal metaphase in a surface segment at the right. The periclinal division of the surface layer is evident on each flank of the apex. Mitoses are also shown in a central mother cell (upper left) and in cells of the peripheral layers (upper right). Note especially the active propagation of the filamentous groups of rib meristem from the basal margins of the zone of central mother cells.





FOSTER GINKGO

1937). However, the well-defined zone of central mother cells is peculiar to Ginkgo and, as far as I am aware, is not duplicated in the shoot tips of the conifers. In the latter, according to the classical investigations of Koch (1891), the meristem is arranged in two zones which are clearly defined as to cell structure and mode of growth, viz.: (1) an outer "Hüllgewebe" composed of several layers of typical meristematic cells which produce the epidermis, cortex, procambium and foliar organs and (2) an inner core or "central tissue" of somewhat vacuolated cells which form the pith. It is clear from Koch's descriptions and excellent drawings that unlike the condition in Ginkgo, the rib meristem (i.e. his "central tissue") in the shoot apices of conifers is propagated directly from a small subterminal group of "mother cells." The latter, except in their position and predominant periclinal division, resemble in size, form and dense cytoplasm the neighboring cells of the "Hüllgewebe" and hence show none of the definitive characteristics of the central mother cells of Ginkgo (cf. Plates 25-27). Koch's observations have been confirmed in a recent study by Korody (1937) for the shoot tips of Abies, Picea and Pinus. This investigator makes a sharp distinction between the "Bildungselement" (i.e. the "corpul-like" terminal region of the apex) and the "Strukturelemente" (i.e. the embryonic layers and the central tissue) in the growing point. Her descriptions, drawings and photomicrographs again emphasize that the "mother cells," from which the two "structural elements" are propagated, are not comparable either in extent or histological features to the central mother cells of Ginkgo. On comparative grounds it is interesting to note that Härtel (1938 pp. 165-166) finds a marked resemblance between the general structure and growth of the shoot apex in the conifers and that typical of various species of Lycopodium. In the latter however, only the subapical "mother cells" are polygonal in form and the "central tissue" arising from them consists of small elongated spindle-shaped cells which differentiate into the vascular tissue of the protostele.

In view of the archaic and probably primitive morphology of Ginkgo, it would be tempting to argue that the distinctive structural features of its shoot apex typify a "primitive stage" in the evolution of the apical meristem of seed plants. For the present however, a rather conservative viewpoint seems preferable because of the debatable relationship between Ginkgo, the conifers and the flowering plants (cf. Sprecher 1907 p. 198) and Chamberlain (1935 p. 433–436) and particularly because our knowledge of the comparative anatomy of apical meristems in the spermatophytes is still very meagre. Strasburger (1872) and Schüepp (1926 pp. 50 and 55) have both suggested that the architecture of the shoot apex in gymnosperms serves to articulate the condition found in Lycopodium with

that typical of angiosperms. Indeed in Araucaria according to Strasburger (1872, taf. XXIII, fig. 13) the outer surface layers of the shoot correspond in mode of arrangement to Hanstein's (1868) "dermatogen" and "periblem" and hence resemble the tunica zone of a dicotyledon. Nevertheless our present knowledge seems insufficient to deduce with confidence the phylogenetic development of the stratified condition of the apical meristem typical of the angiosperms. Korody (1937) has approached the problem from the theoretical standpoint advanced by Buder (1928). She maintains that because of the single tier of apical initials in Abies, Picea and Pinus, the entire apical meristem may be homologized with the corpus region of the shoot apex in angiosperms. A similar conclusion is reached for Lycopodium by Härtel (1938). I cannot agree with this interesting theory however, because it is based upon too rigid a morphological distinction. In my opinion, tunica and corpus represent interdependent growth zones in an apical meristem and as such, one cannot exist independently of the other. Consequently, in agreement with Schüepp (1926, 1927) I would regard the condition in the Abietaceae as indicative of a transitional stage in the evolution of the zonation typical of the shoot tip in angiosperms. From this viewpoint, it may subsequently prove correct to interpret the structural pattern in Ginkgo as an even lower stage in the evolutionary sequence.

In conclusion, it seems fitting to emphasize the need for a complete re-examination, along broad comparative lines, of the architecture and modes of growth of the shoot apex in gymnosperms. It would be particularly interesting to explore the situation in the cycads, since they play such an important rôle in evolutionary theory. The older literature dealing with the apical meristem in gymnosperms seems to have dealt largely with the question of the existence of an apical cell (for resumés of the literature cf. Koch 1891, Schüepp 1926 and Korody 1937). However, the recent studies of Helm (1932), Louis (1935), Barthelmess (1935) and Kaplan (1937) indicate the increasing tendency to emphasize the behavior of entire cell complexes during embryonic growth and differentiation, rather than the "destiny" of individual cells. This attitude has guided the present investigation and if consistently applied in comparative studies should increase our understanding of the fundamental interrelationship between growth and structure in the shoot apex of vascular plants.

SUMMARY

The meristem of the apex of spur and long shoots in *Ginkgo* is not uniform in structure but is segregated into five distinctive zones characterized by the size, staining reactions and mode of growth of the component cells.

The uppermost zone is represented by the apical initial group, from which by anticlinal and periclinal divisions respectively, the surface layer and the internal cells of the shoot apex originate. There is no regular sequence in the successive planes of division of the cells of the apical initial group, and the cell net is correspondingly variable in pattern. Furthermore, periclinal divisions are not restricted to the apical initials but occur at any point in the surface layer.

Directly beneath the apical initial group is found the zone of central mother cells which constitutes the most unique feature of the shoot apex. In their large size, irregular arrangement, relatively infrequent divisions and lightly stained protoplasts, the central mother cells diverge from the structural features usually associated with the primordial meristem of seed plants. It is concluded that volume growth predominates in this zone which, in this respect, is analogous to the corpus region of the angiospermous growing point. A puzzling feature of the central mother cells is the presence of thickened areas at the corners or along the sides of many cells or cell groups. These thickenings are provisionally interpreted as local and temporary depositions of intercellular and primary wall substance.

The lateral and basal margins of the central mother cells represent a "transition zone" from which, by means of renewed mitotic activity, are propagated respectively the bulk of the zone of peripheral layers and the zone of rib meristem.

The zone of peripheral layers, because of the small, deeply stained frequently dividing cells which compose it and the notable emphasis on surface growth might be compared with the tunica region of the growing point in angiosperms. However, periclinal divisions may occur at any point so that there is no constancy in the number of cell layers. In terms of differentiation, the epidermis, cortex and procambium of the shoot axis arise respectively from the outer, middle and innermost of the peripheral layers.

The zone of rib meristem consists of short chains of cells in which growth in length and transverse divisions predominate. The number of filamentous series is continually augmented by periclinal or oblique divisions. In the spur shoot, the closely crowded internodes result from the limited period of activity of the rib meristem which, a short distance from the growing point, gives rise to the broad rapidly maturing pith. By contrast, internodal extension in the long shoot is related to the much greater capacity for continued growth and cell division in the rib meristem of both pith and cortical regions.

The shoot apex of *Ginkgo* possesses a unique type of structure which is not duplicated in vascular cryptogams or seed plants. It is suggested that in some respects however it may typify a "primitive stage" in the evolu-

tionary development of the tunica-corpus regions typical of the shoot apex in angiosperms.

UNIVERSITY OF CALIFORNIA, BERKELEY

Literature cited

- Barthelmess, A. 1935. Ueber den Zusammenhang zwischen Blattstellung und Stelenbau unter besonderer Berücksichtigung der Koniferen. Bot. Archiv. 37: 207-260.
- Bower, F. O. 1889. The comparative examination of the meristems of ferns, as a phylogenetic study. Ann. Bot. 3: 305-392.
- Buder, J. 1928. Der Bau des phanerogamen Sprossvegetationspunktes und seine Bedeutung für die Chimärentheorie. Berl. Deut. Bot. Ges. 46: (20)-(21).
- Chamberlain, C. J. 1935. Gymnosperms. Structure and evolution. Chicago. Cross, G. L. 1936. The structure of the growing point and the development of the
- bud scales of Morus alba. Bull. Torrey Bot. Club 63: 451-465.
- of Viburnum rufidulum. Amer. Jour. Bot. 24: 266-276.
- —. 1938. A comparative histogenetic study of the bud scales and foliage leaves of Viburnum Opulus. Amer. Jour. Bot. 25: 246-258.
- Doak, C. C. 1935. Evolution of foliar types, dwarf shoots and cone scales of Pinus. Univ. Ill. Bull. 32 (49).
- Fankhauser, J. 1882. Die Entwicklung des Stengles und des Blattes von Ginkgo biloba L. Wiss. Beilage z.d. Progr. d. städt. Gymn. Bern.
- Foster, A. S. 1934. The use of tannic acid and iron chloride for staining cells walls in meristematic tissue. Stain Technology 9: 91-92.
- -. 1935. A histogenetic study of foliar determination in Carya Buckleyi var. arkansana. Amer. Jour. Bot. 22: 88-147.
- —. 1936. Leaf differentiation in angiosperms. Bot. Rev. 2: 349-372.
- —. 1937. Structure and behavior of the marginal meristem in the bud scales of Rhododendron. Amer. Jour. Bot. 24: 304-316.
- Hanstein, J. 1868. Die Scheitelzellgruppe im Vegetationspunkt der Phanerogamen. Festschr. der Niederrhein. Ges. Natur.-u. Heilkunde: 109-143.
- Härtel, K. 1938. Studien an Vegetationspunkten einheimischer Lycopodien. Beiträge z. Biol. d. Pflanzen 25: 126-168.
- Helm, J. 1932. Untersuchungen über die Differenzierung der Sprossscheitelmeristeme von Dikotylen unter besonderer Berücksichtigung des Procambi-
- Hof, A. C. 1898. Histologische Studien an Vegetationspunkten. Bot. Centralbl. **76:** 65–69, 113–118, 166–171, 221–226.
- Kaplan, R. 1937. Ueber die Bildung der Stele aus dem Urmeristem von Pteridophyten und Spermatophyten. Planta 27: 224-268.
- Kerr, T., and Bailey, I. W. 1934. Structure, optical properties and chemical composition of the so-called middle lamella. Jour. Arnold Arbor. 15: 327-349.
- Kliem, F. 1937. Vegetationspunkt und Blattanlage bei Avena sativa. Beiträge z. Biol. d. Pflanzen 24: 281-310.
- Koch, L. 1891. Ueber Bau und Wachstum der Sprossspitze der Phanerogamen. I. Die Gymnospermen. Jahrb. wiss. Bot. 22: 491-680.

- Korody, E. 1937. Studien am Spross-Vegetationspunkt von Abies concolor, Picea excelsa und Pinus montana. Beiträge z. Biol. d. Pflanzen. 25: 23-59.
- Louis, J. 1935. L'ontogénese du système conducteur dans la pousse feuillée des Dicotylées et des Gymnospermes. La Cellule 44: 87–172.
- Lyon, H. L. 1904. The embryogeny of *Ginkgo*. Minnesota Bot. Studies 3rd ser. part III, p. 275-290.
- Newman, I. V. 1936. Studies in the Australian acacias. VI. The meristematic activity of the floral apex of *Acacia longifolia* and *Acacia suaveolens* as a histogenetic study of the ontogeny of the carpel. Proc. Linn. Soc. N. S. Wales 61: 56-88.
- Priestley, J. H. 1928. The meristematic tissues of the plant. Biol. Rev. 3: 1-20.

 ———. 1929. Cell growth and cell division in the shoot of the flowering plant.

 New Phy. 28: 54-81.
- Schmidt, A. 1924. Histologische Studien an phanerogamen Vegetationspunkten. Bot. Archiv. 8: 345-404.
- Schüepp, O. 1926. Meristeme. Linsbauer's Handb. Pflanzenanatomie IV. Berlin.

 ———. 1927. Die Vegetationspunkte der Pteridophyten, Gymnospermen und Angiospermen. Verhandl. Schweiz. naturforsch. Gesell. 108, p. 171.
- Seward, A. C. and Gowan, J. 1900. The Maidenhair tree (Ginkgo biloba L.). Ann. Bot. 14: 109-154.
- Solms-Laubach, H. G. 1884. Der Aufbau des Stockes von Psilotum triquetum und dessen Entwicklung aus der Brutknospe. Ann. Jardin Bot. Buitenzorg. 4: 139-194.
- Sprecher, A. 1907. Le Ginkgo biloba L. Genève.
- Strasburger, E. 1872. Die Coniferen und die Gnetaceen. Jena.
- Vidal, L. 1912. La croissance terminale de la tige et la formation des bourgeons chez L'Equisetum palustre. Ann. Sci. nat. sér. 9. 15: 1-38.
- Wagner, N. 1930. Ueber die Mitosenverteilung im Meristem der Wurzelspitzen. Planta 10: 1-27.
- ——. 1937. Wachstum und Teilung der Meristemzellen in Wurzelspitzen. Planta 27: 550-582.
- West, C. 1917. A contribution to the study of the Marattiaceae. Ann. Bot. 31: 361-414.
- Zirkle, C. 1932. Vacuoles in primary meristems. Zeitsch. Zellforsch. und Mik. Anat. 16: 26-47.

Some New and Interesting Late Tertiary Plants from Sucker Creek, Idaho-Oregon Boundary*

HELEN V. SMITH (WITH PLATES 28 AND 29)

In this paper are descriptions of six new species and records of seven species not previously reported from Sucker (i.e., Succor) Creek. Sucker Creek is mostly in Malheur County, southeastern Oregon, and flows in a northerly direction near the Idaho-Oregon boundary line finally crossing into Owyhee County, Idaho, where it empties in the Snake River.

Collections were made from the Miocene lake beds during the summers of 1931, 1932, 1934, and 1936 from three principal localities. In the lower part of the valley specimens were obtained from several beds close to the old Ballantyne Ranch house in Idaho and two or three miles farther up the creek near an old coal prospect. In the upper part of the valley the collections were made from several beds within three or four miles of the Rockville, Oregon, postoffice. There do not appear to be any notable variations among the fossils of the same species collected at the various localities, and the plant associations represented are apparently the same and of the same age. However, the specific localities for the new species are reported here since more extensive studies may eventually indicate locality variation in the florula.

DESCRIPTION OF SPECIES

Polypodiaceae

Woodwardia deflexipinna n. sp. (Plate 28, figs. 3, 6). Outline of frond unknown; pinnae lanceolate; sterile and fertile pinnae alike; pinnae cut three fourths of the distance to the midrib; pinnules broadly lanceolate, rounded at the apex, broadest at base, 1 cm. long, not auricled; margin entire and slightly revolute in some specimens; mid-vein of pinnae and pinnules with a single series of oblong, very slightly oblique areoles on each side; outer veins free, ending along the margin; sori linear or oblong, one to each aerole.—Type, no. 20014, Mus. Paleont., Univ. of Mich. Collected near Rockville, along the Strode Ranch road east of the postoffice.

The living species to which this fossil seems to be most closely allied is Woodwardia virginica (L.) Smith (Plate 28, fig. 2), the common chain fern of eastern North America. In venation, size and distribution of the sori, the entire margin, and rather spreading pinnae the two forms are practically identical.

Among the eight fossil species of Woodwardia from the western states this is closest to W. Maxoni Knowlt. and W. crenata Knowlt. from the

^{*} Papers from the Department of Botany of the University of Michigan no. 661.

Eocene. The Sucker Creek species differs from these particularly by having an entire instead of serrate margin and in the smaller size of the pinnules.

At one locality on the east side of the valley near Rockville, Oregon, this species is extremely abundant. A ledge several inches thick is a mass of fern fragments and many immature rolled up fronds are also common.

Equisetaceae

Equisetum octangulatum n. sp. (Plate 28, fig. 1). Stem 4.5 mm. wide; internode 3.3 cm. long; 4 or 5 longitudinal ribs visible; 5 small branch scars, and no leaves visible at the node.—Type, no. 20013 Mus. Paleont., Univ. of Mich. Collected near the Ballantyne Ranch.

The fragment figured here is the only well preserved specimen in the collection. In spite of its poor representation it seems to be advisable to report the species.

Pinaceae

Pinus sp. (Plate 28, fig. 8). Needles short, in groups of three; rigid; slender, sharply pointed; 2.7 cm. long.

These needles differ from those assigned to *P. Knowltoni* Chaney (3) in being more rigid, narrower, and considerably shorter. They are very straight and not curved as they often are in *P. Knowltoni*.

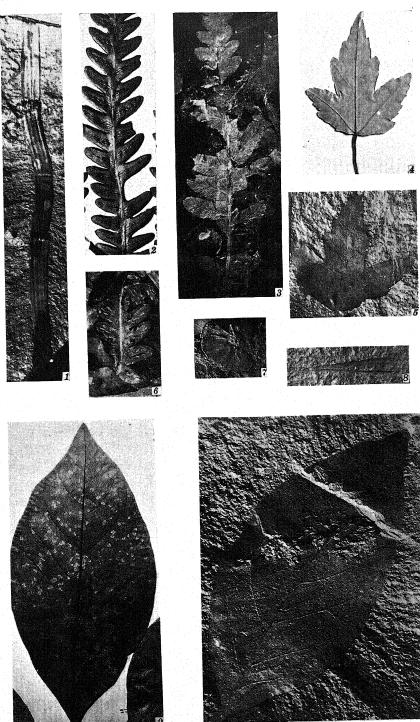
The short *Pinus* needles from Salmon, Idaho, figured by Brown (1) in Plate 45, fig. 10 may represent the same species.

Betulaceae

Betula Bendirei Knowlt. (Plate 29, fig. 3). The single specimen referred to this species is practically identical with leaves of the living B. occidenta-

Explanation of Plate 28

- Fig. 1. Equisetum octangulatum H. V. Smith. Type; Mus. Paleont., Univ. of Mich. no. 20013.
- Fig. 2. Woodwardia virginica (L.) Smith. Specimen from Bloomfield, Michigan in the Herbarium, Univ. of Mich.
- Fig. 3. Woodwardia deflexipinna H. V. Smith, Type; Mus. Paleont., Univ. of Mich. no. 20014.
- Fig. 4. Acer Buergerianum Miq. Specimen from the Botanical Gardens, Univ. of Mich.
 - Fig. 5. Acer Bolanderi Lesq.
 - Fig. 6. Woodwardia deflexipinna H. V. Smith. Fertile pinnule.
 - Fig. 7. Dipteronia insignis (Lesq.) R. W. Brown.
 - Fig. 8. Pinus sp.
- Fig. 9. Nyssa aquatica L. Specimen from Richland Co., Ohio in Herbarium, Univ. of Mich.
- Fig. 10. Nyssa oregonensis H. V. Smith. Type; Mus. Paleont., Univ. of Mich. no. 20015.



HELEN SMITH: TERTIARY PLANTS

lis Hook. This living species occurs along the borders of streams, and margins of meadows in rich moist humous, sandy, and rocky soils. It is found from southwestern British Columbia to northern Washington and east to the Rocky Mountains.

Among fossil species this seems to be most similar to *B. lacustris* MacG. from Trout Creek, Oregon. The Trout Creek species is closely related to *B. fontinalis* Sarg. which was long confused with *B. occidentalis*.

Although the specimen in this collection does not correspond exactly with that figured by Knowlton (4), it is referred to his species because of its resemblance to *B. occidentalis* which he considered to be similar to his fossil. It also answers to Knowlton's description.

Fagaceae

Quercus malheurensis n. sp. (Plate 29, fig. 1). Leaves subcoriaceous, rather small, length up to 7 cm. (estimated), width to 4.5 or 5 cm.; sparsely lobed; lobes rounded, not bristle tipped, one or two on each side of leaf, the lower much larger than the upper; apex of leaf broadly rounded; base cuneate; midrib and lateral veins strong, somewhat undulate; principal lateral veins extending to the tips of the lobes; smaller veins opposite or alternate, relatively weak, curving upward in an irregular manner and becoming effaced; tertiary venation not visible; ultimate venation a fine regular reticulum.—Type, no. 20010 Mus. Paleont., Univ. of Mich. Collected near the old Ballantyne Ranch house.

These leaves belong to the white oak group and resemble some of the sparsely lobed small leaves of Q. alba L. They differ from previously figured fossil oaks of this group chiefly in the small number of lobes and small size, and when a larger series of specimens becomes available may be found to represent a small form of some previously described species. For the present, however, it would be merely guessing to place this fossil with any described form, and there would be the great disadvantage that it might lead to confusion in the record of the other species to which it was referred.

Rutaceae

Ptelea enervosa n. sp. (Plate 29, fig. 6). Samara almost round, winged all around, 2 seeded; seed cavity 4 mm. wide, 6 mm. long; total length of samara 1.7 cm.; total width 1.8 cm.; wing firm, with no visible venation.—Type, no. 20011, Mus. Paleont., Univ. of Mich. Collected near the old Ballantyne Ranch.

A single samara was found in the lower Sucker Creek Valley. It is readily distinguishable from P. miocenica Berry by its smaller size and the firm wing with no visible venation. Among living forms examined this is closest to P. mollis M. A. Curtis var. cryptoneura Bartlett (Plate 29, fig. 7). The living plant has samaras of the same size and shape and the veins are

likewise very indistinct. It occurs in the southeastern states. No leaves referable to Ptelea have been observed in the collection.

Anacardiaceae

Rhus oregonensis n. sp. (Plate 29, fig. 9). Leaf membranaceous, 4.5 cm. wide, 6.5 cm. long; palmately deeply three-lobed or compounded; leaflets pinnate; terminal leaflet broadest just below the middle, tapering cuneately below and having two pairs of small rounded lobes or teeth above; apex apparently acuminate; lateral leaflets with three lobes above and four below, the basal inferior lobes of each lateral leaflet much larger, quite distinct and extending downward; secondary veins enter the shallowly toothed lobes; tertiary venation obsolete; sinuses between the three main lobes very narrow.—Type, no. 20012 Mus. Paleont., Univ. of Mich., collected near Rockville, Oregon.

The leaf was compared with specimens of three genera that may have leaves of this general type; Acer, Panax, and Rhus. Superficially similar leaf forms are found in P. trifolium L. and P. quinquefolium L. The differences are rather marked, neither has the small prominent basal lobe, the former has smaller more numerous marginal teeth and the latter has much narrower lobes than the fossil. As these are both low-growing herbaceous forms the chances of anything related to them entering the fossil record would be extremely slight. Various deeply dissected trifoliate leaves of Acer, especially of A. Negundo L. and A. glabrum Torrey approach this type. The greatest degree of similarity, however, is found with various species of Rhus, especially with R. trilobata Nutt. and to some extent with R. Toxicodendron L. The fossil differs from R. trilobata chiefly in having the small basal lobes arising almost or quite at the top of the petiole.

No similar species of Rhus have been previously reported from the western Miocene. As pointed out by Brown (2) the leaf described as R. diluvialis Arnold from Carter Creek is probably a specimen of Acer Osmonti Knowlt.

Aceraceae

Dipteronia insignis (Lesq.) Brown. (Plate 28, fig. 7). A single specimen that unfortunately has a small portion missing appears to be identical with the samaras figured by Brown (1) as Dipteronia insignis. He says that this species is related to D. sinensis Oliver of central and western China. No leaves referable to this species have been detected in the Sucker Creek material.

Acer Bendirei Lesq. (Plate 29, fig. 4) Under this name Brown (1) includes the leaves and fruits of Acer previously designated by several different names, that appear related to A. macrophyllum Pursh. Three samaras but no leaves referable to this species, are included in my Sucker Creek collections.

Acer Bolanderi Lesq. (Plate 28, fig. 5; Plate 29, fig. 8). This species is represented by several small specimens that are closely similar to the small leaves figured by Lesquereux (6) from the Auriferous Gravels of California. The leaves are trilobate, with entire or sparsely toothed margins, broadly cuneate base and straight or curved midrib.

The leaves were originally compared with A. tripartum Nutt. as to shape and with A. grandidentata Nutt. as to size and consistency. In writing about the specimens from Eagle Creek Chaney (4) pointed out certain similarities with A. saccharum Marsh. However, a closer resemblance is evident with A. Buergerianum Miq. (Plate 28, fig. 4). The leaves studied were taken from plants growing at the Botanical Gardens of University of Michigan. The leaves of this species are like the fossils in the small size, prominent primary veins, character of the lobes, and the weak or obscure tertiaries. A. Buergerianum is native to Japan and China.

Acer negundoides MacG. (Plate 29, fig. 5). This species was described from seeds that resemble those of the living A. Negundo L. It was described by Mac Ginitie (7) from Trout Creek and has since been reported from a number of western Miocene localities. The samaras do not usually occur in association with perfect leaflets and few figures of the leaves have been given. LaMotte (5) has recently figured a complete leaflet of an A. Negundo type found in association with the fruits. His collection contained a single lateral leaflet that differs in several particulars from the one figured here. The leaflet of A. Negundo figured (Plate 29, fig. 2) for comparison was taken from a tree at the Botanical Gardens of the University of Michigan and came from Nebraska. No samaras referable to this species have been noted in this collection.

Explanation of Plate 29

Fig. 1. Quercus malheurensis H. V. Smith. Type; Mus. Paleont., Univ. of Mich. no. 20010.

Fig. 2. Acer Negundo L. Leaflet from Botanical Gardens, Univ. of Mich.

Fig. 3. Betula Bendirei Knowlt.

Fig. 4. Acer Bendirei Lesq.

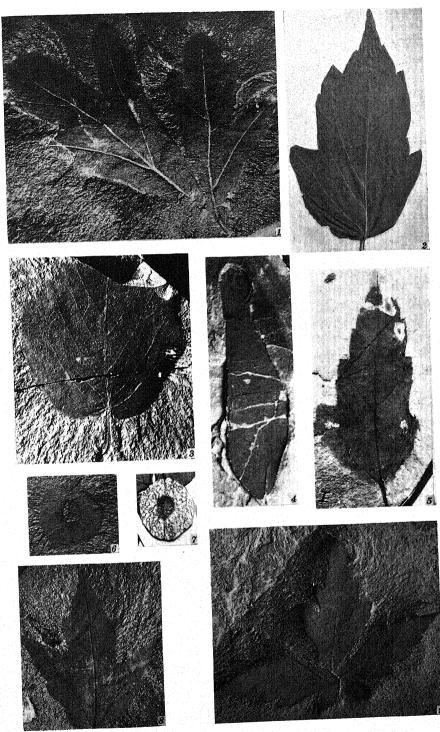
Fig. 5. Acer negundoides MacG.

Fig. 6. Ptelea enervosa H. V. Smith. Type; Mus. Paleont., Univ. of Mich. no. 20011.

Fig. 7. Ptelea mollis M. A. Curtis var. cryptoneura Bartlett. Specimen from McDuffie Co., Georgia, in Herbarium, Univ. of Mich.

Fig. 8. Acer Bolanderi Lesq.

Fig. 9. Rhus oregonensis H. V. Smith. Type; Mus. Paleont., Univ. of Mich. no. 20012.



HELEN SMITH: TERTIARY PLANTS

Cornaceae

Nyssa oregonensis n. sp. (Plate 28, fig. 2). Leaves subcoriaceous, 9.5 cm. long, 4.3 cm. broad; ovate, widest about the middle, tapering to an acuminate apex and cuneate base; margin entire; midrib fairly strong, straight or slightly curved, secondaries about 10 pairs, parallel, alternate or occasionally subopposite, arising at an acute angle, finer nervation a very fine distinct reticulum.— Type no. 20015 Mus. Paleont., Univ. of Mich. Collected near Rockville, Oregon.

This sub-coriaceous entire-margined leaf is similar to leaves of *Benzoin aestivale* (L.) Nees and *Diospyrus virginica* L., but is still more like certain leaves of *Nyssa aquatica* L. (Plate 28, fig. 8). This single specimen leaves little doubt as to the presence of *Nyssa* of the *N. aquatica* type in the Sucker Creek beds. No fruits of *Nyssa* are included in this collection.

Three leaf species of Nyssa have been described from the western Miocene, but all differ in significant ways from this species. N. crenata Chaney from Bridge Creek and Eagle Creek has a crenate margin, a greater regularity in the spacing of the secondaries, and has percurrent tertiaries. N. hesperia Berry differs markedly from this species in the less regular venation, the arching of the secondaries well within the margin, the percurrent tertiaries and in the much broader shape. N. Knowltoni Berry is more elliptical, has a more prominent midrib and distinctly percurrent tertiaries.

The five modern species of *Nyssa* are native to southwestern Asia and southeastern America. *N. aquatica* occurs in cypress and other swamps from Virginia to Missouri and southward to Florida and Texas.

University of Michigan, Ann Arbor, Michigan

Literature Cited

- Brown, R. W. 1937. Additions to some fossil floras of the western United States. U. S. Geol. Surv. Prof. Paper 186-J.
- 2. ——. 1937. Further additions to some fossil floras of the western United States. Jour. Wash. Acad. Sci. 27: 506-517.
- 3. Chaney, Ralph W. 1920. The flora of the Eagle Creek formation. Contr. Walker Mus. 2 (5).
- 4. Knowlton, Frank H. 1902. Fossil flora of the John Day Basin. U. S. Geol. Surv., Bull. 204.
- 5. LaMotte, Robert S. 1936. The Upper Cedarville flora of northwestern Nevada and adjacent California. Carnegie Inst. Wash. Pub. 455: 57-142.
- 6. Lesquereux, Leo. 1878. Report on the fossil plants of the Auriferous Gravel deposits of the Sierra Nevada. Mus. Comp. Zool., Mem. 6 (2).
- 7. MacGinitie, Harry D. 1933. The Trout Creek flora of southeastern Oregon. Carnegie Inst. Wash. Pub. 416: 98-118.

New species of cacti from Guatemala, Mexico and Texas*

ELZADA U. CLOVER (WITH 7 FIGURES)

Echinocereus Gentryi sp. nov. (figs. 1, 2, 3). Caespitosus, caulibus 2–4, decumbentibus vel erectis, 6–15 cm. altis, 2–2.5 cm. crassis; costis 5, rectis, summitate spiralibus, vix tuberculatis; spinis 8–12 lateralibus radiatis, porrectis, acicularibus, albis vel fuscis; centrali saepe solitaria; omnibus fuscis; basi bulbosis, deciduis; areolis 1 mm. latis, rotundis; floribus magnis, 6–8 cm. longis, 5–6 cm. latis, roseis; segmentis perianthii 5-seriatis, stylo albo; stigmatis lobis 8, viridibus; filamentis numerosis, antheris rufis; fructibus viridescentibus. Specimen typicum vivum ex loco "Saucito" dicto in Sonora, Mexico conservatum est in Horto Botanico Universitatis Michiganensis; atgru floribus siccis in Herb. Mich.

Echinocereus Gentryi n. sp. (figs. 1, 2, 3). Caespitose, stems procumbent to ascending, few, jointed 6-15 cm. high, 2-2.5 cm. broad; ribs 5, indistinct, spiral, especially toward the top, tubercles scarcely visible; areoles minute, 1 mm. or less across, circular, 3-4 mm. apart; radial spines 8-12, acicular, 1-2 mm. long, bulbous at the base, more or less deciduous, on very young stems white, often 4-5 mm. long; on new growth of older stems, shorter, brownish; young areoles white wooly, in age naked; central spine usually solitary, rarely 2-5, similar to radials, sometimes darker brown; blossoming in April from areoles 5 to 7 cm. from the tip, flower funnelform, 6-8 cm. long, 5-6 cm. across, tube 3-4 cm. long, perianth segments in 5 whorls, the outer ones bract-like, curling back, olive-drab, inner segments amaranth pink to Tyrian pink, lanceolate, apiculate; style exerted, white to very pale green, stigma lobes 7-8, emerald green; filaments pink above, white below; anthers red; pollen deep yellow; ovary globose, 1.5 cm. across at maturity, greenish, bracts very small, olive-drab, areoles circular, containing somewhat cobwebby wool, spines 8-20, white to pinkish brown, 4-5 mm. long, longer on flower tube than on ovary.

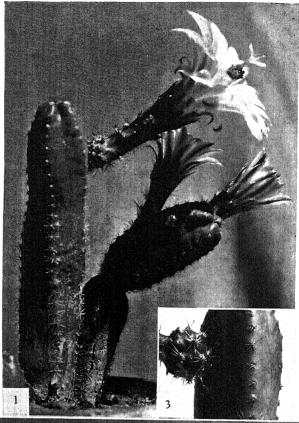
Flowers in the greenhouse open fully about 3:00 p.m. and remain almost fully open all night.

This species is apparently closely related to *E. subinermis* described by Salm-Dyck in 1856 from Chihuahua, Mexico. That species, however, has a shorter flower tube, style included, and is yellow. The author was unable to get either herbarium of living specimens of *E. subinermis*, since it apparently has never been recollected. Comparisons were made from descriptions and photographs. This new species was collected at Saucito, Sonora,

Mexico by H. S. Gentry in 1932.

Echinocereus Steereae sp. nov. (fig. 4). Simplex vel caespitosus, caulibus erectis, 8–12 cm. altis, ca. 6 cm. crassis; costis 16–18, tuberculis parvis; spinis

* Papers from the Department of Botany and the Botanical Gardens of the University of Michigan, No. 662.



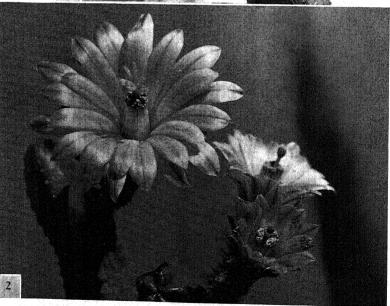


Fig. 1. Echinocereus Gentryi in flower. (About two thirds natural size.)
Fig. 2. Flowers of same.
Fig. 3. Fruit of same. (About natural size.)

lateralibus 16–24, acicularibus, albis vel rosaceis, centralibus plerumque 3–5, in serie singula verticali dispositis, areolis ellipticis; floribus magnificis, 10–11 cm. longis, 14–15 cm. latis, segmentis perianthii 5-seriatis, exterioribus, fusco-olivaceis margine, pallide viridibus parte media roseopurpureis; stylo viridi; stigmatis lobis 12; filamentis viridibus; antheris luteis; fructibus ignotis. Specimen typicum vivum ex Montibus Texensibus "Chisos" dictis conservatum est in Horto Botanico Universitatis Michiganensis, Ann Arbor, Michigan; atque floribus siccis in Herb. Mich.

Echinocereus Steereae n. sp. (fig. 4). Plant simple or caespitose, with pinkish white appearance, not at all banded, largest stem seen 12 cm. long, 6 cm. across; ribs 16-18, tubercles distinct, small, flattened dorso-ventrally, alternating with those on adjoining ribs; areoles short-elliptic, if young densely white-wooly (wool lacking in older areoles), 5-7 mm. apart; radial spines 16-24, interlocking, 3-5 spines at the upper end of areole shorter, others about equal, spreading and slanting downward at an angle of 45 degrees; central spines 3-5, usually in a single row, bulbose at the base, shorter than the lower radials, stouter than the upper radials, usually a deeper pink. Flowering in April from areoles almost halfway up the stem to within 3 cm. of the top; flowers ascending or standing at right angles to the stem, very showy, 10-11 cm. long, 14-15 cm. across; perianth segments in 5 whorls, the inner three rose-purple with whitish margins, 7-7.5 cm. long, 2 cm. across near center of segment, very narrow at the base and obtuse to cuspidate at the tip, somewhat erose; tinged with greenish-yellow toward the inside center, grading to deep turtle green at the center; outermost segments uneven, 1.5-3 cm. long, tapering to a very narrow tip, olive-drab in midline, pale green and petal-like at the smooth margin, second whorl 5-7 cm. long, olive-drab in midline, pale green tinged with rose-purple toward the margin; style extending 1 cm. beyond the stamens, white, 2 mm. in diameter, included, stigma lobes dark green, 12, somewhat fused, slightly recurved, decurrent; filaments greenish, anthers pale yellow; ovary 5 cm. long, 1.75 cm. across, its areoles 1 cm. apart, circular, prominently white-wooly, with spines 14-15, spreading, rigid, acicular, 4-5 mm. long, white with brown tips; bracts bright green, tipped with pink, 2 mm. long, narrow; fruit unknown.

Collected by Mrs. Lois Steere in the Chisos Mts., western Texas, March, 1937.

Rhipsalis Bartlettii sp. nov. (figs. 6, 7). Ramosissima, ramis pendulis, filiformibus, dichotomis, rarius verticillatis, pallide viridibus; areolis prominentis, dense lanatis, lana lutea-fusca; fructibus albis, globosis. Specimen typicum siccatum legit H. H. Bartlett sub numero 12720 ex "Uaxactun," Petén, Guatemala, in Herb. Univ. Mich.

Rhipsalis Bartlettii n. sp. (figs. 6, 7). Hanging epiphyte, branches 2 m. long, weak and pendent, branching dichotomous, sometimes verticillate, light green, outer joints often less than 1 mm. in diameter, areoles prominent, filled with

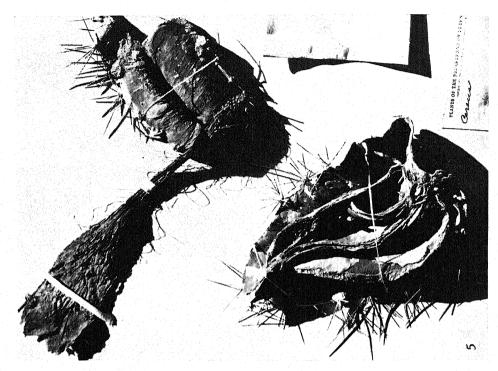


Fig. 5. Deamia diabolica.

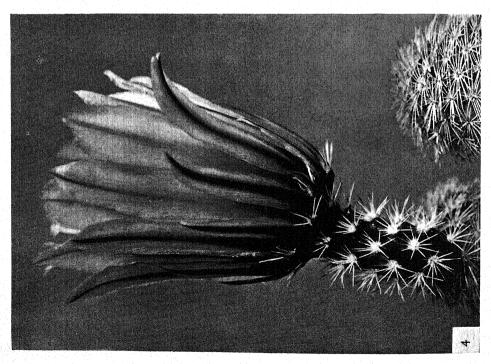
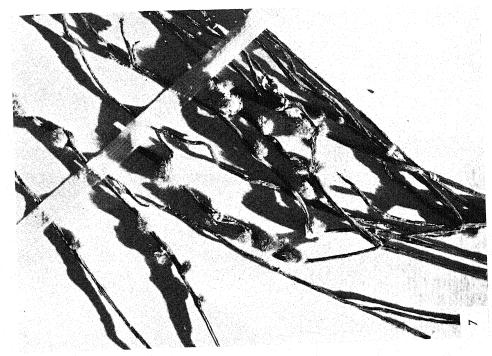


Fig. 4. Echinocereus Steereae in flower. (Slightly less than natural size.)





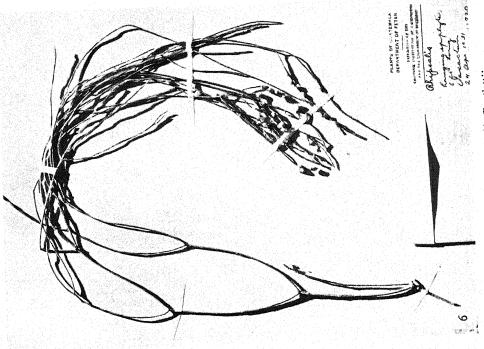


Fig. 6. Habit of Rhipsalis Barllellii.

dense masses of tawny hairs, these 2–3 mm. long; flowering areoles not lanate, ovary sunken in the branch, fruit white, globose, 3–4 mm. in diameter; seeds black, reniform, less than 1 mm. long, testa reticulate furrowed. Flower unknown. Specimens were collected by H. H. Bartlett, Uaxactun, Petén, Guatemala, April 24, 1931. A single less ample specimen was collected for the University of Michigan Herbarium by E. Matuda at Cordoba, Vera Cruz, Mexico, August 14, 1936.

Deamia diabolica sp. nov. (fig. 5). Planta fruticulosa volubilis probabiliter ut in *D. Testudine* densissime epiphytica in arboribus humilibus prope litora, inferne ramosissimis, ramis radicantibus; costis 4–5 altissimis alatis, acutis, subcrenatis; spinis 12–20, dissimilibus, 5–52 mm. longis, acicularibus vel nonnihil triquetris, basi bulbosis, fuscis; floribus albis, 22–24 cm. longis tubo 9–11 cm. longo, setoso; ovario spinoso. Specimen typicum siccatum in Herb. Mich., Ann Arbor, Mich.

Deamia diabolica n. sp. (fig. 5). Stems robust, jointed, 3-4 angled, ribs thin and wing-like 3-4 cm. high, subcrenate, areoles on edges of wings 1.5-2 cm. across on mature stems; spines stout, various, 5-52 mm. long, brown, becoming grayish, bulbose at the base, acicular, terete to somewhat 3 angled, longer ones slightly curving, one spine in an areole often much longer than others; flower 22-24 cm. long, white, tube about 12 cm. long, bracts on tube small. areoles 1.5 cm. apart above, closer below, filled with tawny wool and usually 3 brown to yellowish, curling hairs 1-3 cm. long; inner perianth segments white, spathulate, apiculate, outer segments much shorter, linear greenishwhite; style stout, extending beyond the stamens, stigma lobes 7; ovary ovate, densely spiny, spines golden-brown, acicular, interlocking, 3-5 cm. long, semirigid, areoles circular, filled with tawny wool; seeds about 2 mm. long, brown, shiny, subreniform, testa slightly reticulate. Specimens collected by Percy Gentle in the Corozal District, British Honduras, 1931-32. No. 490. Additional specimens were collected by Mercedes Aguilar La Libertad, Petén, Guatemala, June 7, 1934, no. 262.

Notes on American melastomes, including nine new species

H. A. GLEASON

Rhynchanthera paludicola comb. nov. Tibouchina paludicola Donn. Sm. Bot. Gaz. 42: 293. 1906. In his original description the author mentioned the five sterile stamens and the slender beaks of the fertile anthers and remarked that these were abnormal characters for the genus. They are however perfectly normal characters for Rhynchanthera, section Isostemones. The species is related to R. Hookeri of the northern Andes, from which it differs in its larger flowers, much longer sepals, and the fewer and much longer glandular hairs of the hypanthium.

The only other North American species of the genus *Rhynchanthera* is *R. mexicana* DC., of southern Mexico and Panama. This is a member of the section *Anisostemones*, in which the connective of one stamen is greatly prolonged.

The genus *Centradenia* was credited with four species by Cogniaux in 1891. This number may now be increased to seven, all natives of the mountains and adjacent foothills of Mexico and Central America, extending south as far as Panama. The generic description given by Cogniaux needs a slight revision: the anthers are sometimes quite isomorphic; while often oblong or ovoid, as stated, they may also be linear-oblong or subulate, and in these narrower forms are acuminate.

Brandegee's two species, C. chiapensis and C. salicifolia, are both valid and belong to the section Eucentradenia, characterized by strongly dimorphic anthers. C. chiapensis and C. grandifolia, with ebracteate flowers, glabrous hypanthium, and wide, strongly falcate leaves, are clearly related. In the latter the leaves are 4-nerved and the stem prominently winged; in the former the leaves are 3-nerved or 5-nerved and the stem merely 4-angled. C. salicifolia and C. Bernoullii, with glandular hypanthium and fairly broad leaves, are also related. In the latter the appendages of the larger stamens are terminated by two slender elongate lobes or setae, while in the former they are merely shallowly lobed.

In the section *Centradeniopsis*, characterized by stamens isomorphic or nearly so, a seventh species may now be described, differing from *C. floribunda* in its linear-subulate anthers with truncate appendages:

Centradenia Maxoniana sp. nov. Caules graciles, erecti (?), subflexuosi, subteretes, dense strigosi, pilis subulatis 0.6 mm. longis e basibus satis tumidis. Petioli foliorum majorum graciles, 2–5 mm. longi, strigosi. Laminae firmulae, supra virides, subtus pallidiores, lanceolatae, usque 10 cm. longae 2.2 cm. latae, acuminatae, integrae, paulo falcatae, basi inaequilaterales, latere uno longe cuneatae, altero obtusae vel rotundatae, 4-pli-nerviae, venis supra fere

planis subtus paulo elevatis, supra setosae, pilis gracilibus circa 0.5 mm. longis, subtus superficie glabrae ad venas strigosae, pilis rigidis 0.8 mm. longis. Folia minora subulata vel anguste lanceolata, 1-2 cm. longa, mox decidua. Cymulae 3-10-florae, caulem et ramulos ex axillis superioribus terminantes, pedunculis pedicellisque dense glanduloso-pubescentibus, pedicellis 3-5 mm. longis. Hypanthium anguste campanulatum, 8-costatum, 3.5 mm. longum, glanduloso-pubescens, pilis gracilibus adscendentibus 0.4-0.5 mm. longis, summo setis validioribus ornatum. Sepala triangularia e sinibus late rotundatis, 1 mm. longa, acuta, glabra vel fere glabra. Petala oblonga, 5 mm. longa, inaequilateralia, minute glanduloso-ciliata. Stamina isomorpha sed magnitudine inaequalia; filamenta 2-2.3 mm. longa; thecae lineari-subulatae. fere rectae, 2.8 vel 4 mm. longae, convolutae; connectivum brevissime productum, ad filamenti apicem oblique dilatatum, parte anteriore adscendente, quadrata, 0.5 mm. longa, parta posteriore descendente, ovata, 0.2 mm. longa. Ovarium obovoideo-oblongum, 2.8 mm. longum, glabrum; stylus gracilis, 6 mm. longus.

Type, Pittier 5414, collected between Hato del Jobo and Cerro Vaca, eastern Chiriquí, Panama, alt. 700–1000 meters, and deposited in the United States National Herbarium. Other specimens are Williams 321, from Panama; Pittier 11061 and Tonduz 7628, from Costa Rica.

The genus Chaetolepis is primarily South American, with one species, C. alpina Naud., ranging north into Costa Rica. In western Cuba and the Isle of Pines the genus appears again, and from this rather restricted area Cogniaux recognized four species, C. saturaeoides Triana, C. cubensis Triana, C. brevistrigillosa Cogn., and C. Grisebachii Cogn. Careful examination of the ample material preserved in American herbaria has failed to disclose any reliable evidence which might indicate specific differences among them. They have been separated on such notoriously variable characters as the proportions and density of pubescence on the leaves, the shape and number of scales and hairs on the stem and hypanthium, the size and shape of the sepals, and the number of flowers, and in all of these features they intergrade freely. I therefore propose their union into a single species under the oldest specific name, Chaetolepis cubensis (A. Rich.) Triana.

The generic name *Heeria* was maintained by Triana and by Cogniaux because of its supposed priority of one year over *Heterocentron*, and in spite of the fact that *Heeria* was a later homonym. The next available name is apparently *Heterocentron*, which was used by Krasser and by Rose. Actually *Heterocentron* was published in 1838, a year earlier then *Heeria*, so that there can be no doubt of the proper name for this genus of Mexican and Central American plants.

Of greater importance is the possible segregation of the genus into two,

as was recommended by Rose, who very properly adopted *Schizocentron* Meissn. for the smaller group. In it the plants are decumbent or creeping, instead of erect, the flowers are solitary, instead of paniculate, and in the better known species the leaves are 3-nerved, instead of multipli-nerved. These characters give the plants an entirely different facies, but they are not supported by floral structures. In consistency with the standards used elsewhere in the family, the two groups must be kept within a single genus, as was done by both Triana and Cogniaux.

Cogniaux admitted six species in 1891. Since then four species have been added, *H. occidentalis* Rose in 1905, *H. suffruticosa* Brandg. in 1914, *H. alata* Rose & Standl. and *H. laxiflora* Standl. in 1924. I shall here describe four species as new, make two segregations from species previously recognized but recently united, and combine two old species into one, leaving the genus with fifteen species as recognized by me.

Heterocentron subtriplinervia, originally described by Link & Otto in the genus Melastoma, is the most abundantly represented species in most herbaria. In transferring the species to Heterocentron, Braun and Bouché noted that the difference between it and H. rosea was slight, the latter having an ovarial crown of four scales which was lacking in the former. Examination of an excellent series of specimens shows that this character is variable and that no other constant character can be found to separate them. H. rosea is accordingly reduced to synonymy.

The section *Euheeria* contained a single species, *H. elegans* (Schlecht.) Kuntze, in 1891. To this Brandegee added in 1914 an excellent species, *H. suffruticosa*, its hypanthium strigose with non-glandular hairs, rather than glandular-hirsute, and its leaves multipli-nerved, rather than 3-nerved. A third species of the group may now be described, agreeing with *H. elegans* in the characters above mentioned but differing in its sessile upper leaves and in its sepals exceeding the hypanthium.

Heterocentron sessilis sp. nov. Fruticulus, caulibus gracilibus elongatis sarmentosis, subteretibus sed angustissime 4-alatis, sparse strigosis praesertim ad alas; internodia usque 5-10 cm. longa. Petioli graciles, 2-4 mm. longi, sparse strigosi. Laminae ovatae vel ovato-oblongae, 15-25 mm. longae 8-12 mm. latae, acutae, crenatae, ad basin late acutae usque rotundatae, 3-nerviae, supra et ad venas venulasque subtus sparse setosae, venis secundariis more Melastomatacearum nullis sed vena media venulas laterales curvatas emittenti; foliorum juga 1 vel 2 superiora sessilia, lata ovata, cirça 8 mm. longa 5 mm. lata, basi rotundata vel subcordata. Flores solitarii, ramos laterales terminantes, pedunculis 2-3 cm. longis glabris gracilibus. Hypanthium campanulatum 4 mm. longum hirsutum, pilis patulis vel subreflexis 1.5 mm. longis basi incrassatis. Sepala erecta vel adscendentia, triangulari-lanceolata,

acuminata, minute ciliata, ceterum glabra, hypanthium paulo excedentia. Petala rubro-purpurea 10 mm. longa. Stamina modo generis. Ovarium apice glanduloso-setosum.

Type, von Türckheim II 1554, collected at Coban, Dept. Alta Verapaz, Guatemala, alt. 1550 meters, and deposited in the Gray Herbarium of Harvard University. Von Türckheim 2470 in the Field Museum and the National Herbarium is the same. The type number in the Field Museum and the National Herbarium, von Türckheim II 2364 in the same herbaria, and von Türckheim 2471 in the National Herbarium represent an intermediate form between, and possibly a hybrid of, this species and H. glandulosum Schenck. They are characterized by paniculate flowers on short glandular pedicels and by larger leaves, many of which exhibit the multiple venation so characteristic of most species of the genus.

The remaining twelve species of *Heterocentron* may be divided into two groups, one of six species with glandular-hirsute hypanthium and one of five species with strigose non-glandular hypanthium, with a twelfth species of doubtful relationship.

In the first group two species are found in the western part of Mexico, in the states of Jalisco, Durango, Sinaloa, and Nayarit; in these the ovary is not setose at the summit. One of these, *H. mexicana* Hook. & Arn., the type of the genus, was combined by Cogniaux with *H. subtriplinervia*. Examination of original material shows that it is quite distinct. Related to it is an undescribed species, distinguished by glabrous and entire sepals, those of *H. mexicana* being glandular-ciliate and usually also pubescent on the back. It also differs in its larger panicle, its much larger flowers, and the stouter hairs of the hypanthium. This is:

Heterocentron floribunda sp. nov. Caules erecti graciles, acute 4-angulati, 4-sulcati, tenuiter canescentes punctis minutis albis, internodiis glabris, nodis sparse setosis. Petioli graciles 5-10 mm. longi, sparse strigosi. Laminae tenues, ovato-ellipticae, pallide virides, 3-6 cm. longae 1.5-3 cm. latae, integrae, utrinque acutae, multipli-nerviae, jugis lateralibus 4 vel 5, supra et subtus ad venas sparsissime setosae, pilis gracilibus circa 0.5 mm. longis. Panicula elongata ramosa multiflora, ramis angularibus, sparse pubescens, pilis patulis circa 0.3 mm. longis, iis pedicellorum glandulosis; pedicelli supremi fere glabri, 5-8 mm. longi, bracteis 2 subulatis 1.5-2 mm. longis sustenti. Hypanthium late campanulatum, 4.3 mm. longum, pubescens, pilis patulis vel curvatoadscendentibus glandulosis 0.4-0.6 mm. longis, e basibus depresso-conicis 0.3-0.4 mm. altis. Sepala ovato-lanceolata vel triangularia, 5.5 mm. longa, basi 2.5 mm. lata, anguste acuminata, glabra, integra. Petala late obovata, 9 mm. longa 8 mm. lata, integra, venosa, conspicuiter inequilatera, vena media curvata. Filamenta gracilia, 4.5 vel 6 mm. longa; thecae 3.5 vel 4.6 mm. longae; connectiva staminum exteriorum paulo curvata, 2.7 mm. longa, infra

thecas paulo incrassata, appendice complanata, anguste clavata, obtusa, 2.4 mm. longa. Ovarium liberum glabrum; stylus sigmoideus 7 mm. longus.

Type, Ortega 5329, collected at Sianori, Durango, and deposited in the United States National Herbarium. Other collections, all from Durango, are Ortega 4272, Palmer 102, and Rose 3509.

The remaining four species in the group are natives of more southern regions, ranging from Jalisco to Costa Rica. Two of them, *H. glandulosa* Schenck and *H. axillaris* Naud., have glabrous entire sepals. They were united by Cogniaux, but may be distinguished specifically by the glandular-hirsute pedicels of the former and the strigose non-glandular pedicels of the latter.

The last two have glandular-pubescent, glandular-ciliate sepals. In H. undulata Naud. the setae of the ovary are non-glandular, the sepals are shorter than the hypanthium, and the connective of the longer stamens is half as long as its appendage. In the other, described below as new, the ovarian setae are glandular, the sepals exceed the hypanthium, and the connective is longer than the appendage.

Heterocentron salvadorana sp. nov. Suffruticosa, 1 m. alta, caulibus acute 4-angulatis, supra tomentulosis, demum glabrescentibus. Petioli 5–8 mm. longi. Laminae firmulae, ovato-ellipticae, 3–7 cm. longae 2–3 cm. latae, obtusae, integrae, basi late cuneatae, multipli-nerviae, utrinque tenuiter pubescentes. Panicula magna multiflora, pedicellis brevibus dense glandulosis. Hypanthium subglobosum, 2.8 mm. longum, dense glanduloso pubescens, pilis patulis 0.3 mm. longis. Sepala ad anthesin reflexa, ovata, 3.2 mm. longa, basi 2.2 mm. lata, apice involuta, glanduloso-ciliata, ciliis 0.1 mm. longis, glanduloso-pubescentia. Petala late obovata, 5 mm. longa 4 mm. lata, glanduloso-ciliata, pilis 0.1 mm. longis. Filamenta 4 vel 5.5 mm. longa; thecae 2.8 vel 3.5 mm. longae; connectivum staminum majorum supra filamentum fere rectum 2 mm. longum, infra filamentum in calcara 2 subulata divisum. Ovarii squamae semicirculares erectae, 0.4 mm. altae, densissime glanduloso-ciliatae, pilis fere contiguis, usque 0.8 mm. longis, fructu persistentibus.

Type, Standley 20398, collected at Santa Ana, Dept. Santa Ana, Salvador, and deposited in the United States National Herbarium.

Recent collections from Chiapas have disclosed a fourth undescribed species, marked by excellent morphological characters but of doubtful relationships. This is:

Heterocentron muricata sp. nov. Caulis partes superiores acute 4-angulatae, glabrae vel levissime strigosulae, ad nodos dense breviterque barbatae. Laminae membranaceae, oblongae, 2-4 cm. longae, 1-2 cm. latae, breviter abrupteque acuminatae, ad basin late cuneatae in petiolum brevem superne alatum, supra minutissime strigosulae, subtus sparse strigosae, praecipue ad

venas. Ramuli floriferi ex axillis superioribus divaricati, pauciflori, superne strigosi; pedicelli veri 4–8 mm. longi gracillimi glabri. Hypanthium subglobosum, 4.5 mm. longum, valde muricatum, muricis ca. 1 mm. longis, ceterum glabrum. Sepala anguste triangularia 6.5 mm. longa, ad anthesin reflexa, nunc integra, nunc brevissime sparseque ciliata. Petala staminaque non visa, sed connectivum unum 1.9 mm. longum alte bilobum, anthera unica 2.6 mm. longa. Ovarium apice squamis 4 quadrato-ovatis glanduloso-ciliatis coronatum; stylus gracilis sigmoideus 8 mm. longus, stigmate punctiformi.

Type, Matuda 1967, collected at Montecristo, Chiapas, January, 1938, without further data, and deposited in the Britton Herbarium at the New York Botanical Garden. Although in general habit our plant somewhat resembles H. suffruticosa Brandg., also from Chiapas, it differs notably in its muricate hypanthium and its squamiferous ovary. The latter feature indicates a possible relation to the group of five species mentioned previously, including the common H. subtriplinervium A. Br. & Bouché, but none of this group has a muricate hypanthium. Stoutly subulate hypanthial hairs are characteristic of H. undulata Naud., but in that species glandular pubescence is abundant, the hypanthium is much smaller, and the sepals only 2–2.5 mm. long.

David Don established the genus Arthrostemma in 1823, crediting it to Pavon, and including five species which are now assigned to three different genera in as many different tribes of the family. As a result, it accumulated many unrelated species during the next fifty years, and several of its species were segregated under various generic names. Triana accepted the genus in the sense of Ruiz and Pavon in 1871 and it was so continued by Cogniaux in 1891. Three North American species were recognized by Cogniaux, A. fragile Lindl., A. campanulare Triana, and A. parvifolium Cogn.

The characters of the genus, as regularly understood since the work of Triana, are definite. The flowers are 4-merous, with slender elongate hypanthium and short triangular sepals; petals large, fugacious or caducous; stamens dimorphic; anthers linear; connective conspicuously prolonged below the thecae, bearing a large anterior appendage, 2–3-toothed or lobed at its apex; ovary free, 4-celled.

Triana described A. alatum in 1871 from Venezuelan material without flowers. Flowering specimens are now available from Panama and Salvador and show that the anthers are nearly isomorphic, quite small, ovoid in shape, with a very short connective bearing a subulate spur. Notwithstanding these discrepancies, the plant is obviously a good Arthrostemma, and the generic description must be revised accordingly.

Cogniaux described A. parvifolium from Guatemalan material without flowers, and in 1904 Donnell Smith described A. apodocarpum from the

same country. Comparison of the types shows that these two species are identical. Smith dismissed the structure of the anthers in five words, "stamina parva inaequalia" and "antheris parvulis." Here also they are short, ovoid in shape, nearly isomorphic, with a short connective bearing a flat truncate spur. Clearly A. alatum and A. parvifolium are closely related. In the latter the leaves are acute to cuneate at the base and the filaments are glandular-pubescent; in the former the leaves are rounded to subcordate at the base and the filaments are glabrous.

A. hirtellum Cogn. was described from Guatemalan material in fruit. So far as known to me, it has been collected but once and I have seen three specimens of this type collection. Flowers are absent, although Cogniaux describes the anthers in terms that might well apply to an Arthrostemma, but without stating dimensions or proportions. The plant differs notably from all other species of the genus in its short, broadly campanulate hypanthium, its elongate sepals, and its setose ovary, and there can be little doubt that it is not an Arthrostemma. Its generic affiliation cannot be settled until flowering material can be examined.

The well known name Arthrostemma campanulare Triana (1871) is not tenable, being a later homonym antedated by Arthrostemma campanulare DC. (1828). It has been replaced by A. macrodesmum Gl.; Williams, Fl. Trin. & Tob. 356, 357. 1934.

The genus *Monochaetum* is represented in North America by seventeen species, all montane or subalpine in their distribution. Two of these are known only from recent collections and are described below. They suggest that further exploration in the less accessible mountains of Central America may reveal still other species.

Monochaetum compressum sp. nov. Frutex ramosissimus usque 2 m. altus, caulibus gracilibus hirsutulis, pilis e basibus papillosis leviter retrorsis, internodiis 5-10 mm. longis. Petioli 1-3 mm. longi patentim hirsuti. Laminae firmulae oblongae vel oblongo-lanceolatae, 5–17 mm. longae 3–6 mm. latae, acutae vel obtusae, integrae, basi obtusae vel rotundatae, levissime 3-plinerviae, supra virides sparse strigosae, venis primariis leviter impressis, secundariis obsoletis, subtus pallidae molliter villosae, venis secundariis obscuris reticulatis. Flores solitarii, ramulos breves terminantes, pedicellis hirsutis, quam hypanthio brevioribus. Hypanthium fusiformi-campanulatum 8–9 mm. longum, sparse hirsutum, pilis eglandulosis patulis 0.6-0.8 mm. longis e basibus papillosis. Sepala patentia oblongo-triangularia, 5.6 mm. longa 2.4 mm. lata, ciliata, dorso sparse hirsuta, pilis non papillatis. Petala pallide purpurea circa 15 mm. longa. Stamina interiora: Filamenta 10 mm. longa; antherae erectae subulatae 6.2 mm. longae; appendices adscendentes oblongae 3.3 mm. longae. Stamina exteriora: Filamenta 9 mm. longa; antherae arcuatae 9–10 mm. longae; appendices 5 mm. longae dorso alte canaliculatae, lateribus adpressis. Ovarium summo villosum, pilis erectis 0.9 mm. longis; stylus 7.5 mm. longus.

Type, Skutch 1516, collected on the south slope of Volcano Atitlan, Dept. Suchitepequez, Guatemala, alt. 2400 meters, and deposited in the Britton Herbarium at the New York Botanical Garden. In its freely branched stem and small leaves, M. compressum has a superficial resemblance to M. Deppeanum Naud. It differs from that species in its larger anthers and in the shape of its anther-appendages. These features, together with its large flowers and papillate pubescence of minutely barbellate hairs, indicate its relationship to M. macrantherum Cl. It is distinguished from this species by its hirsute pubescence on stem and hypanthium and by its 3-pli-nerved leaves which are uniformly pubescent on both sides.

Monochaetum rubescens sp. nov. Frutex parce ramosus, caulibus praeter nodos minutissime setosos glabris rubescentibus. Petioli graciles 5-10 mm. longi glabri. Folia membranacea ovato-lanceolata vel ovata, maxima usque 42 mm. longa 19 mm. lata, superiora minora, acuminata, minutissime serrulata, dentibus seta adpressa brevi terminatis, basi acuta vel abrupte cuneata, 3-5-pli-nervia, supra opaca vel rubescentia, glabra, venis primariis angustissime impressis secundariis obsoletis, subtus pallida sparsissime setosa, venis primariis leviter elevatis, secundariis obscuris flexuosis. Flores 1 vel 3, caulem et ramos 2 supremos terminantes, pedicellis quam hypanthio dimidio brevioribus glabris. Hypanthium campanulatum rubro-purpureum 7 mm. longum, glabrum praeter setas paucas breves terminales. Sepala patentia rubropurpurea oblongo-ligulata 7.5 mm. longa 3 mm. lata, acuta, ciliata, setis 1-3 ornata ceterum glabra. Petala purpurea late obovata 20-25 mm. longa. Stamina interiora: Filamenta complanata 10 mm. longa; antherae erectae subulatae 4.4-4.7 mm. longae; appendices curvato-erectae anguste ellipticae 4 mm. longae 0.9 mm. latae. Stamina exteriora: Filamenta 8.5 mm. longa; antherae arcuatae circa 10 mm. longae; appendices ad apicem dilatatae teretes 5 mm. longae. Ovarium ad apicem sparse setosum; stylus glaber 7.5 mm. longus.

Type, Matuda 0932, collected at Siltepec, Chiapas, and deposited in the herbarium of the University of Michigan. Matuda 1015, from Mt. Pasitar, Chiapas, agrees with the type in every detail. Matuda 0973, from Mt. Orando, Chiapas, has somewhat longer leaves, reaching 60 mm. in length and only 20 mm. in width. The few-flowered inflorescence, the almost complete absence of pubescence, and especially the terete appendages of the larger anthers indicate that M. rubescens belongs to the species-group

¹ Am. Jour. Bot. 16: 586-594, 1929,

Pringleae. The three (or possibly four) species hitherto known have shorter sepals and conspicuously strigose or glandular hypanthia.

The huge genus *Miconia*, already with nine hundred described species, continues to receive additions in many parts of its range. The two described below are both well marked and abundantly distinct from the species hitherto known.

Miconia filamentosa sp. nov. Sect. Eumiconia: arbuscula; rami superiores teretes graciles, tenuissime stellato-puberuli, internodiis 3-8 cm. longis. Folia in quoque jugo subaequalia. Petioli 2-5 mm. longi, minute stellato-puberuli. Laminae tenues oblongae vel oblongo-lanceolatae vel anguste lanceolatae, usque 12 cm. longae 3 cm. latae, anguste acuminatae, conspicue obcrenatae, ad basin minute cordulatam angustatae, 3-nerviae vel fere 3-pli-nerviae, supra glabrae, subtus ad venas sparsissime stellato-puberulae, venis secundariis 2-3 mm. dissitis sub angulo 80° divergentibus. Panicula terminalis, 6–8 cm. longa lataque, ubique densiuscule stellato-puberula, ramis oppositis divaricatis, ad nodos omnes lineari-bracteolata, bracteolis 0.8 mm. longis. Flores 5-meri, sessiles in cymulis trifloris sed flores laterales ut videtur pedicellati. Hypanthium obconicum, ad torum 1.8 mm. longum, stellato-puberulum. Calycis tubus nullus vel usque 0.2 mm. longus, sepalis e sinibus acutis semicircularibus vel triangularibus, 0.5 mm. longis, rotundatis vel acutis, minutissime ciliatis, dentibus exterioribus crasse conicis. Petala anguste obovato-oblonga, 3 mm. longa 1.3 mm. lata, glabra, paulo retusa. Stamina dimorpha. Filamenta gracillima, 4.6 vel 2.3 mm. longa. Antherae lineares, 3 vel 2.3 mm. longae, poro terminali latiusculo dehiscentes. Connectivum staminum majorum infra thecas 0.7 mm. productum et in lobum obliquum rotundatum, filamentum fere amplectentem expansum, staminum minorum 0.4 mm. productum et in lobum 1 rectum dorsalem et lobos 2 laterales deflexos divisum. Ovarium semiinferum, 4-loculare, summo rotundatum, minute pubescens, obscure 10lobatum, ovulis in quoque loculo circa 8; stylus gracilis glaber, 5.5 mm. longus; stigma minute capitatum.

Type, Klug 938, collected at Mishayacu, near Iquitos, Dept. Loreto, Peru, in forest at an altitude of 100 meters, and deposited in the Britton Herbarium at the New York Botanical Carden. In Williams 3306, a fruiting specimen with less crenate leaves and a panicle up to 20 cm. long, the fruit is spherical and about 2 mm. in diameter. In Krukoff 8936, from São Paulo de Olivenca, Brazil, the flowers and pubescence are essentially identical with the type, but the leaves are much broader at the base and deeply cordate, consequently appearing subsessile. M. filamentosa has been compared with practically every described species of the section. It is probably nearest to M. Sprucei Triana, in which the leaves are much wider, more abruptly acuminate, essentially entire, and entirely lacking the heart-shaped base.

Miconia incurva sp. nov. Sect. Amblyarrhena: frutex 9 m. altus, caulibus. petiolis, foliorum pagina inferiore, inflorescentia, hypanthiis, et calycibus ferrugineo-stellato-tomentosis. Rami graciles demum glabrescentes, internodiis 1-2 cm. longis. Petioli satis graciles 5-10 mm. longi. Laminae tenues, oblongolanceolatae, maximae 13 cm. longae 3.5 cm. latae, anguste acuminatae, integrae, basi obtusae vel late acutae, 3-pli-nerviae ca. 1 cm. supra basin, supra glabrae; venae primariae supra impressae, submarginalibus validis, secundariae 2-3 mm. dissitae, sub angulo fere recto divergentes. Paniculae ca. 5 cm. longae lataeque, ramis oppositis; bracteae persistentes triangulari-subulatae 2-4 mm. longae; cymulae triflorae. Flores 5-meri. Hypanthium obconicum carnosum, ad torum 6.7 mm. longum, intus obscure costatum. Calycis tubus fere erectus, 3.3 mm. altus, lobis brevissimis truncatis subscariosis, margine libero fere nullo, dentibus exterioribus flexuosis incurvis subulatis 7 mm. longis. Petala alba, late obovata, valde obliqua, basi subunguiculata, 10-11 mm. longa lataque. Stamina isomorpha; filamenta glabra 5.5 mm. longa, medio leviter dilatata, infra antheram subito contracta; antherae oblongae, 4.7 mm. longae, 2-loculares, poro minuto ventrali-terminali dehiscentes, connectivo incrassato non producto. Ovarium inferum 5-loculare, summo concavo circum stylum annulato; stylus crassus teres 14 mm. longus, stigmate capitato subgloboso, 2 mm. diametro.

Type, Skutch 3273, collected at Vara Blanca de Sarapiqui, north slope of Central Cordillera, Costa Rica, alt. 1500–1700 meters, and deposited in the Britton Herbarium at the New York Botanical Garden. While the plant is obviously a Miconia, with anthers externally resembling the typical form of the section Amblyarrhena, it is exceptional for the section in having only two loculi in the anthers. Very few species of the section have elongate exterior teeth, and they differ notably in other structural features.

NEW YORK BOTANICAL GARDEN.

INDEX TO AMERICAN BOTANICAL LITERATURE 1935-1937

The aim of this Index is to include all current botanical literature written by American, published in America, or based upon American material; the word America being used in the broadest sense.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the index may be addressed to the Treasurer of the Torrey Club.

- Adams, J. The flora of Canada. Canada Year Book 1938: 30-58. 1938.
- Afanasiev, M. A physiological study of dormancy in seed of Magnolia acuminata. Cornell Agr. Exp. Sta. Mem. 208: 1-37. f. 1-11. S 1937.
- Ames, O. Additions to the genus Acoridium. Blumea Suppl. I Jubilee vol. 66-77. 1937.
- Anderson, E. G. Translocation in maize involving chromosome 9. Genetics 23: 307-313. My 1938.
- Anderson, E. & Turrill, W. B. Statistical studies on two populations of Fraxinus. New Phytol. 37: 160-172. f. 1, 2. 29 Ap 1938.
- Anderson, P. J. Downy mildew of tobacco. Connecticut Agr. Exp. Sta. Bull. 405: 65-82. f. 1-5. D 1937.
- Arnold, C. A. Paleobotanical studies in Michigan. Papers Michigan Acad. Sci. 23: 95-99. Ap 1938.
- Arnold, C. A. Paleozoic seeds. Bot. Rev. 4: 205-234. f. 1-14. My 1938.
- Baehni, C. Esquisses de géographie botanique Américaine. Boissiera 2: 9-30. 1937.
- Bailey, L. H. The Calyptrogyne-Calyptronoma problem—the Manac palms. Gentes Herb. 4: 153-172. f. 86-100. Ap
- Bailey, L. H. The Copernicia puzzle in Jamaica. Gentes Herb. 4: 185. Ap 1938.
- Bailey, L. H. Native bactrids of the Great Antilles. Gentes Herb. 4: 173-184. f. 101-110. Ap 1938.
- Baines, R. C. Mint anthracnose. Phytopathology 28: 103-113. f. 1-4. F 1938.
- Baker, M. F. Florida wild flowers. i-xiii. 1-245. illust. 1938.
- Baker, R. E. D. Citrus scab disease on grapefruit in Trinidad. Jour. Imp. Coll. Trop. Agr. 15: 77-79. Ap 1938.
- Baker, R. E. D. Red root disease of limes in the British West Indies. Jour. Imp. Coll. Trop. Agr. 15: 105-108. My 1938.

- B[aker], R. E. D. Swollen shoot of cacao. Jour. Imp. Coll. Trop. Agr. 15: 110-111. My 1938.
- Barros, M. Notas Ciperologicas. Lilloa Rev. Bot. 1: 67-69. 1937.
- Bartram, E. B. The second Byrd Antarctic expedition—botany. III. Mosses. Ann. Missouri Bot. Gard. 25: 719-724. Ap 1938.
- Baxter, D. V. Some resupinate Polypores from the region of the Great Lakes. IX. Papers Michigan Acad. Sci. 23: 285-305. pl. 1-9. 1938.
- Baxter, D. V., Labaree, B. & Hildebrand, W. On and off Alaskan trails. 1-184. illust. 1937.
- Beath, O. A. Seleniferous vegetation of Wyoming. Wyoming Agr. Exp. Sta. Bull. 221: 34-64. illust. My 1937.
- Beath, O. A. & others. Three species of Zygadenus (Death Camas). Wyoming Agr. Exp. Sta. Bull. 194: 1-39. f. 1-18. Ap. 1933.
- Beckenbach, J. R., Robbins, W. R. & Shive, J. W. Nutrition studies with corn. II. A statistical interpretation of the relation between the ionic concentration of the culture solutions and the element content of the tissues. Soil Sci. 45: 403-426. f. 1-6. My 1938.
- Beckett, R. E., Stitt, R. S. & Duncan, E. N. Rubber content and habits of a second desert milkweed (*Asclepias erosa*) of southern California and Arizona. U. S. Dept. Agr. Tech. Bull. 604: 1-11. f. 1-3. F 1938.
- Benoist, R. Phanerogames nouvelles de l'Amérique méridionale. Bull. Soc. Bot. France 84: 632-639. f. 1, 2. D 1937.
- Bevel, N. Key to the common aquatic and emergent plants of Reelfoot Lake. Jour. Tennessee Acad. Sci. 13: 120-125. Ap 1938.
- Billington, C. The vegetation of Cranbrook Lake bottom, Oakland County, Michigan. Cranbrook Inst. Sci. Bull. 11: 1-20. pl. 1. Mr 1938.
- Bingham, M. T. A study of vegetational invasion and succession on a denuded area of the Cranbrook estate, Bloomfield Hills, Michigan. Papers Michigan Acad. Sci. 23: 101-108. pl. 1-5. Ap 1938.
- Bitancourt, A. A. Relação das doencas e fungos parasitas observados na seccao de phytopathologia durante os annos 1935 e 1936. Arch. Inst. Biol. São Paulo 8: 315-322. 1937.
- Black, L. M. A study of potato yellow dwarf in New York.

 Cornell Agr. Exp. Sta. Mem. 209: 1-23. pl. 1-4. N 1937.
- Brieger, F. G. Alguns aspectos physiologicos da Accao dos gens. Rodriguesia 3: 187–198. f. 1–4. S–D 1937.

Brieger, F. G. & Graner, E. A. Asyndese em Lilium longiflorum. Rodriguesia 3: 157-165. S-D 1937.

Brinkman, A. H. Hepatics of the Pacific coast and adjoining states. Rep. Prov. Mus. Nat. Hist. Br. Columbia 1937: 21–23. 1938.

Brooks, C. & McColloch, L. P. Spotting of figs on the market. Jour. Agr. Res. 56: 473-488. f. 1-12. 1 Ap 1938.

Brown, H. P. Trees of northeastern United States, native and naturalized. 1-490. Rev. Ed. Boston, Christopher Publ. Co. 1938.

Brown, J. R. Euphorbia Caput—Medusae. Jour. Cactus & Succ. Soc. Am. 9: 171-173. illust. My 1938.

Brown, J. R. Notes on Haworthias. Jour. Cactus & Succ. Soc. Am. 9: 86-87. D 1937; 133-134. illust. F 1938; 139. illust. Mr 1938.

Brown, R. W. Two fossils misidentified as shelf-fungi. Jour. Washington Acad. Sci. 28: 130-131. Mr 1938.

Bruman, A. J. Genetic aspects of plant introduction. An approach to the heredity-environment problems in plants. Sci. Monthly 46: 120-131. illust. F 1938.

Buchanan, T. S. Blister rust damage to merchantable western white pine. Jour. Forestry 36: 321-328. f. 1. Mr 1938.

Buchholz, J. T. Cone formation in Sequoia gigantea. I. The relation of stem size and tissue development to cone formation. II. The history of the seed cone. Am. Jour. Bot. 25: 296-305. f. 1-12. Ap 1938.

Burkhart, A. Estudios morfologicos y etologicos en el genero Prosopis. Darwiniana 3: 27-47. pl. 1-6. 1937.

Burkhart, A. Las especies Argentinas del genero Centrosema. Darwiniana 3: 7-25. pl. 1, 2. 1937.

Cabrera, A. L. Compuestas Argentinas nuevas o interesantes.

Inst. Mus. Nac. La Plata Notas Bot. 2: 171-204. pl. 1-4.

Cabrera, A. L. Notas sobre los Senecios Sudamericanos. Inst. Mus. Cien. Nat. La Plata 1: 389-408. 1936.

Cain, S. A. The species-area curve. Am. Midl. Nat. 19: 573-581. f. 1-5. My 1938.

Campos Porto, P. Excursão a campos do Jordão. Rodriguesia 2: 113-119. Je-S 1937.

Carpenter, D. C. Anatomy of the inflorescence of Urginea maritima (L.) Baker. Papers Michigan Sci. 23: 109-115.

pl. 1. Ap 1938.

Carrion, A. L. Actinomycosis in Puerto Rico. Puerto Rico. Jour. Publ. Health & Trop. Med. 13: 367-382. pl. 1-10. Mr 1938.

- Castellanos, A. El genero de las asclepiadaceas *Hickenia* Lillo. Lilloa Rev. Bot. 1: 71-74. pl. 1. 1937.
- Castellanos, A. & Lelond, H. V. Los generos de las cactaceas Argentinas. An. Mus. Argentino Cien. Nat. 39: 383-419. pl. 1-12. 25 Ap 1938.
- Chamberlain, G. C. Yellow blotch-curl: a new virus disease of the red raspberry in Ontario. Canadian Jour. Res. 16: 118–124. pl. 1, 2. Mr 1938.
- Chatters, R. M. The effect of fast neutrons on dry seeds. Science 87: 262-263. 18 Mr 1938.
- Clokey, I. W. Notes on the flora of the Charleston Mountains, Clark County, Nevada. Bull. So. Calif. Acad. Sci. 37: 1-11. pl. 1, 2. Ja-Ap 1938.
- Cochran, H. L. A morphological study of flower and seed development in pepper. Jour. Agr. Res. 56: 395-419. f. 1-16. 15 Mr 1938.
- Cockerell, T. D. A. San Miguel Island, California. Sci. Monthly 46: 180-187. illust. F 1938.
- Coker, R. E. Function of an Ecological Society. Science II. 87: 309-315. 8 Ap 1938.
- Collins, J. L. & Kerns, K. R. Mutations in the pineapple.

 Jour. Heredity 29: 163-172. f. 1-4+frontispiece. My 1938.
- Cook, E. S., (Sister) Mary Jane Hart & Joly, R. A. The effect of 1, 2, 5, 6,—dibenzanthracene on the growth and respiration of yeast. Science II. 87: 331. 8 Ap 1938.
- Cooper, W. C. Effect of root formation of retreating cuttings with growth substances. Science II. 87: 390. 29 Ap 1938.
- Copeland, E. B. Hymenophyllum. Philippine Jour. Sci. 65: 1-188. pl. 1-89. S-O 1937.
- Crocker, W. Life-span of seeds. Bot. Rev. 4: 235-274. My 1938.
- Crocker, W. Studies with seeds and germination. Mo. Bull. Hort. Soc. N.Y. 1-7. illust. Mr-Ap 1938.
- Croizat, L. Acer japonicium var. Parsonsii Hort. (Veitch & Sons) ex Schwerin, an invalid trinomial. Bull. Fan Mem. Inst. Biol. 7: 197-199. 26 D 1936.
- Croizat, L. Identifying the lindens. Am. Nurseryman 67: 7-8. illust. 15 F 1938;
- Croizat, L. Une nouvelle espice de Kalanchoe du Mozambique. Bull. Jard. Bot. Bruxelles 14: 363-366. pl. 9+f. 26. D 1937.
- Cross, G. L. A comparative histogenetic study of the bud scales and foliage leaves of *Viburnum opulus*. Am. Jour. Bot. 25: 246-258. f. 1-47. Ap 1938.

Cuatrecasas, J. Plantae novae Colombianae. Rev. Acad. Colombiana 1: 362-375. f. 1-18. 1937.

Darlington, H. T. Lichens collected in the Porcupine Mountains, northern Michigan. Papers Michigan Acad. Sci. 23: 117-121. Ap 1938.

Darrah, W. C. A new fossil Gleicheniaceous fern from Illinois. Harvard Univ. Bot. Mus. Leafl. 5: 145-159. illust. 11 Mr 1938.

Darrah, W. C. The occurrence of the genus *Tingia* in Texas. Harvard Univ. Bot. Mus. Leafl. 5: 173-188. *illust*. 4 Ap. 1938.

Dawson, R. F. Nicotinic acid and tobacco metabolism. Science 87: 257. 18 Mr 1938.

Degelius, G. Lichens from southern Alaska and the Aleutian Islands, collected by Dr. E. Hulten. Medded. Göteborgs Bot. Trad. 12: 105-144. pl. 1-4. 1938.

Descole, H. R. & O'Donell, C. A. Estudios anatomicos en el Leno de plantas Tucumanas. Lilloa Rev. Bot. 1: 75-93. pl. 1-8. 1937.

Dodge, C. W. & Baker, G. E. The second Byrd Antarctic expedition—botany. II Lichens and lichen parasites. Ann. Missouri Bot. Gard. 25: 515-718. pl. 40-65. Ap 1938.

Dore, W. G. & Groh, H. List of grasses (Gramineae) of the Ottawa district. Canadian Field Nat. 52: 53-55. 2 Ap 1938.

Douglass, A. E. Tree rings and chronology. Univ. Arizona Bull. **8:** 1-36. *pl.* 1-8+f. 1-3. O 1937.

Drouet, F. Myxophyceae of the Yale North India expedition collected by C. E. Hutchinson. Trans. Am. Micros. Soc. 57: 127-131. Ap 1938.

Ducke, A. A Capansa no Acre. Arch. Inst. Pesq. Agron. Pernambuco 1: 20-22. pl. 1. Mr 1938.

Ducke, A. Diversidade dos Guaranas. Rodriguesia 3: 155-156. f. 1-3. S-D 1937.

Dugand, A. Algunas Leguminosas endemicas y de mayor distribucion geografica. Contr. Hist. Nat. Colombiana 1: 7-13. 1938.

Dugand, A. Sobre la denominación de tres Bombacaceas de la Costa Caribe. Contr. Hist. Nat. Colombiana 1: 1-6. 1938.

Egler, F. E. A new species of Hawaiian *Portulaca*. B. P. Bishop Mus. Occ. Papers 13: 167-170. f. 1, 2. 1 Au 1937.

Erichsen, C. F. E. Beiträge zur Kenntnis der Flechten gattung Pertusaria. Repert. Spec. Nov. 41: 77-101. 25 N 1936.

- Erickson, H. D. The flow of liquid through radial resin canals. Jour. Forestry 36: 417–423. f. 1, 2. Ap 1938.
- Ezell, B. D. & Gerhardt, F. Oxidase and catalase activity of Bartlett pears in relation to maturity and storage. Jour. Agr. Res. 56: 337-346. 1 Mr 1938.
- **Ezell, B. D. & Gerhardt, F.** Respiration and oxidase and catalase activity of apple and pear fruits. Jour. Agr. Res. **56**: 365–386. f. 1–8. 1 Mr 1938.
- Farwell, O. A. Notes on the Michigan flora. VII. Papers Michigan Acad. Sci. 23: 123-134. Ap 1938.
- Fassett, N. C. Spring flora of Wisconsin. 1–176. illust. Madison, Wis. Democrat Print. Co. 1938.
- Fassett, N. C., McGary, L. & Bates, L. F. Hayfever plants of the middle west. 1-52. illust. Madison, Wis. 1938.
- Fawcett, H. S. & Bitancourt, A. A. Relatario sobre as doencas dos citrus nos estados de Pernambuco, Bahia, São Paulo e Rio Grande do Sul. Rodriguesia 3: 213-236. S-D 1937.
- Fosberg, F. R. Some Rubiaceae of southeastern Polynesia. B. P. Bishop Mus. Occ. Papers 13: 245-293. f. 1-15. 5 N 1937.
- Fosberg, F. R. & Hosaka, E. Y. An open bog on Oahu. B. P. Bishop Mus. Occ. Papers 14: 1-6. f. 1-2. 7 F 1937.
- Frick, G. A. Habitat of Euphorbia pseudocactus. Jour. Cactus & Succ. Soc. Am. 9: 143-144. illust. Mr 1938.
- Gager, C. S. Pandemic botany. Science II. 87: 285-292. 1 Ap 1938.
- Gates, F. C. Layering in black spruce (*Picea mariana* (Mill.) B.S.P.) Am. Midl. Nat. 19: 589-594. f. 1-4. My 1938.
- Goldsworthy, M. C. & Green, E. L. Effect of low concentrations of copper on germination and growth of conidia of Sclerotinia fruticola and Gomerella cingulata. Jour. Agr. Res. 56: 489-505. f. 1. 1 Ap 1938.
- **Goodspeed, T. H.** Andean plant hunting. New Flora & Silva **10:** 194–198, *f.* 63–66. Ap 1938.
- Greene, H. C. Colony organization of certain bacteria with reference to sporulation. Jour. Bact. 35: 261-272. pl. 1, 2. Mr 1938.
- Grout, A. J. A tentative key to the moss flora of North America. Bryologist 41: 31-36. Ap 1938.
- Groves, J. W. Additions to the Agaricaceae of the Ottawa district. Canadian Field Nat. 52: 57-60. 2 Ap 1938.
- Gustafson, F. G. Further studies on artificial parthenocarpy: Am. Jour. Bot. 25: 237-244. f. 1-7. Ap 1938.

- Hanes, C. R. Additions to the flora of Michigan. Papers Michigan Acad. Sci. 23: 135-139. Ap 1938.
- Harms, H. Eine neue Araliacee aus Colombia. Repert. Spec. Nov. 43: 110. 10 Ja 1938.
- Harms, H. Zwei neue Arten der gattung *Inga*. Repert. Spec. Nov. 43: 111-112. 10 Ja 1938.
- Heimburger, C. & Porsild, A. E. Red spruce in the lower Gatineau Valley. Canadian Field Nat. 52: 72-73. My 1938.
- Hildebrand, E. M. The blossom-blight phase of fire blight, and methods of control. Cornell Agr. Exp. Sta. Mem. 207: 1-40 pl. 1-3+f. 1-4. Au 1937.
- Hoehne, F. C. Orchidaceas do herbareo geral do Musen Goeldi, Belen do Para. Arch. Inst. Biol. São Paulo 8: 267-288. 1937.
- Hosaka, E. Y. Ecological and floristic studies in Kipapa Gulch, Oahu. B. P. Bishop Mus. Occ. Papers 13: 175–232. f. 1–18. 1937.
- Hosie, R. C. Botanical investigations in Batchawana Bay region, Lake Superior. Canada Dep. Mines & Res. Bull. 88: 1-140. 1938.
 Includes a catalogue of the vascular plants by T. M. C. Taylor.
- Hume, H. H. Cohering keels in amaryllids and related plants. Proc. Florida Acad. Sci. 1936: 48–57. pl. 1–3. 1937.
- Ivanoff, S. S., Riker, A. J. & Dettwiler, H. A. Studies on cultural characteristics, physiology and pathogenicity of strain types of Phytomonas Stewarti. Jour. Bact. 35: 235-253. f. 1, 2. Mr 1938.
- Jacques, A. G. The accumulation of electrolytes. IX. Jour. Gen. Physiol. 21: 665-685. f. 1. 20 My 1938.
- Jacques, A. G. & Osterhout, W. J. V. The accumulation of electrolytes. X. Jour. Gen. Physiol. 21: 687-693. 20 My 1938.
- Jahn, A. Prof. Dr. Henry Pittier. Bol. Soc. Venezolana Cien. Nat. 4: 1-43. S-O 1937.
- Jenkins, A. E. & Massey, L. M. Rose anthracnose. Am. Rose Ann. 1938: 136–141. f. 1–3. 1938.
- Jones, D. F. Translocation in relation to mosaic formation in maize. Proc. Nat. Acad. Sci. 24: 208-211. 15 My 1938.
- Kanouse, B. B. Notes on new or unusual Michigan Discomycetes. V. Papers Michigan Acad. Sci. 23: 149-154 f. 1. 1938.
- Kellar, H. A. Solon Robinson pioneer and agriculturist. Vol. 1: 1-582. 1936; Vol. 2: 1-556. 1936.

Killip, E. P. The American species of Passifloraceae. Field Mus. Nat. Hist. Bot. Ser. 19: 1-331. f. 1, 2. 31 Mr 1938; 335-613. 20 Ap 1938.

Kimmey, J. W. Susceptibility of Ribes to Cronartium ribicola in the West. Jour. Forestry 36: 312-320. Mr 1938.

Kittredge, J. The interrelations of habitat, growth rate and associated vegetation in the Aspen community of Minnesota and Wisconsin. Ecol. Mongr. 8: 153-246. f. 1-16. Ap 1938.

Knuth, R. Geraniaceae novae. Repert. Spec. Nov. 40: 216-220. 30 Je 1936.

Koehler, B. & Holbert, J. R. Combating corn diseases in Illinois. Univ. Illinois Agr. Exp. Sta. Circ. 484: 1-35. f. 1-22. Mr 1938.

Krukoff, B. A. Two new species of *Erythrina* from Central America. Phytologia 1: 286–289. My 1938.

Kunitz, M. Formation of trypsin from trypsinogen by an enzyme produced by a mold of the genus *Penicillium*. Jour. Gen. Physiol. 21: 601–620. f. 1–11. 20 My 1938.

La Motte, C. Morphology and orientation of the embryo of *Isoetes*. Ann. Bot. II. 1: 695-715. pl. 26. O 1937.

Lamson-Scribner, F. The Botanical Garden at Rio de Janeiro. Sci. Monthly 46: 5-15. illust. Ja 1938.

Lang, A. G. The origin of lint and fuzz hairs of cotton. Jour. Agr. Res. 56: 507-521. f. 1-3. 1 Ap 1938.

Latzina, E. Index de la flora dendrologica Argentina. Lilloa Rev. Bot. 1: 95-211. pl. 1-10. 1937.

Lauer, K. W. Cedar apple rust and its control. Pennsylvania Dept. Agr. Bull. 21: 1-11. f. 1-4. Ja-F 1938.

Leach, J. G. & Currence, T. M. Fusarium wilt of muskmelons in Minnesota. Minnesota Agr. Exp. Sta. Tech. Bull. 129: 1-32. f. 1-18. Ap 1938.

Lillo, M. Catalogo de las Acantaceas Argentinas. Lilloa Rev. Bot. 1: 21-66. pl. 1-9. 1937.

Lipman, C. B. Importance of silicon, aluminum, and chlorine for higher plants. Soil Sci. 45: 189–198. Mr 1938.

Little, E. L. The vegetation of Muskogee County, Oklahoma. Am. Midl. Nat. 19: 559-572. f. 1-8. My 1938.

Lohman, M. L. Observations on species of *Bulliardella*. Papers Michigan Acad. Sci. 23: 155-162. pl. 1, 2+f. 1. 1938.

Losser, G. El helecho Dennstaedtia glauca (Cav.) C. Chr. Lilloa Rev. Bot. 1: 249-251. 1937.

Lowe, J. L. The distribution of some lichens in North America. Papers Michigan Sci. 23: 163–169. 1938.

- Lugard, E. J. Monadenium lugardae N. E. Br. Jour. Cactus & Succ. Soc. Am. 9: 178-179. illust. My 1938.
- Lundell, C. L. Two new species of *Plenckia*. Phytologia 1: 284–286. My 1938.
- McAlister, D. F. Effect of fungi on the oxidation-reduction potentials of liquid culture media. Am. Jour. Bot. 25: 286-295. f. 1-10. Ap 1938.
- MacArthur, J. W. & Butler, L. Size inheritance and geometric growth processes in the tomato fruit. Genetics 23: 253-268. f. 1, 2. My 1938.
- McCarty, E. C. The relation of growth to the varying carbohydrate content in mountain brome. U. S. Dep. Agr. Tech. Bull. 598: 1-24. f. 1-6. Ja 1938.
- McClure, F. A. Bambusa ventricosa, a new species with a teratological bent. Lingnan Sci. Jour. 17: 57-62. pl. 5. 8 Ap 1938.
- MacGowan, W. L. Growth-ring studies of trees of northern Florida. Proc. Florida Acad. Sci. 1936: 57-65. 1937.
- Machacek, J. E. & Greaney, F. J. The "black-point" or "kernel smudge" disease of cereals. Canadian Jour. Res. 16: 84-113. f. 1, 2+pl. 1. F 1938.
- McMurtrey, J. E. Distinctive plant symptoms caused by deficiency of any one of the chemical elements essential for normal development. Bot. Rev. 4: 183-203. f. 1. Ap 1938.
- Magnusson, A. H. Additional notes on Acarosporaceae. Medded. Göteborgs Bot. Trad. 12: 87-103. 1938.
- Mains, E. B. Host specialization in Coleosporium solidaginis and C. campanulae. Papers Michigan Acad. Sci. 23:171-175. 1938.
- Marchionatto, J. B. Nota biologica sobre el Claviceps Paspali. Rev. Argentina Agron. 4: 147-152. f. 1-5. S 1937.
- Marie-Victorin, Frère. Phytogeographical problems of eastern Canada. Am. Midl. Nat. 19: 489-558. f. 1-68. My 1938.
- Marshall, W. T. & Woods, R. S. Glossary of succulent plant terms. Jour. Cactus & Succ. Soc. Am. 9: 3-8. illust. Mr 1938
- Martin, G. W. Myxomycetes from Colombia. Trans. Am. Micros. Soc. 57: 123–126. f. 1–5. Ap 1938.
- Martin, L. F., Balls, A. K. & McKinney, H. H. The protein content of mosaic tobacco. Science II. 87: 329-330. 8 Ap 1938.
- Martin, R. F. A new species of Callirhoë. Jour. Washington Acad. Sci. 28: 107-109. Mr 1938.
- Meigs, P. Vegetation on shell mounds, lower California. Science II. 87: 346. 15 Ap 1938.

- Metcalf, F. P. Notes on Chinese plants. Lingnan Sci. Jour. 17: 75-77. 8 Ap 1938.
- Meyer, T. Algunos arboles indigenas cultivados en el departamento de Resistencia (Chaco). Lilloa Rev. Bot. 1:233-261. 1937.
- Miller, E. V. A physiological study of the rind color of certain citrus fruits. Science II. 87: 394-395. 29 Ap 1938.
- Moldenke, H. N. Additional notes on the genus Aegiphila. IV. Phytologia 1: 289-304. My 1938.
- Moldenke, H. N. A monograph of the genus *Callicarpa* as it occurs in America and in cultivation. II. Repert. Spec. Nov. 40: 38-131. 31 Mr 1936.
- Moldenke, H. N. Studies of new and noteworthy tropical American plants. III. Phytologia 1: 273-284. My 1938.
- Morton, C. V. Notes on the genus *Saracha*. Proc. Biol. Soc. Washington 51: 75-78. 19 My 1938.
- Muller, C. H. Further studies on the southwestern oaks. Am. Midl. Nat. 19: 582-588. My 1938.
- Myers, W. M. & Powers, L. R. Meiotic instability as an inherited character in varieties of *Triticum aestivum*. Jour. Agr. Res. 56: 441-452. 15 Mr 1938.
- Nelson, A. Taxonomic studies. Univ. Wyoming Publ. 3: 101–112. 1 S 1937.
- Nichols, G. E. Bryophytes of the Huron Mountain region, Marquette County, Michigan. Bryologist 41: 25-31. Ap 1938.
- Nielsen, E. L. & Younge, O. R. Observations on the distribution of *Heuchera arkansana* Rydberg. Am. Midl. Nat. 19: 595-597. f. 1. My 1938.
- Ochoterena, I. Esquemas biotipicos y sinecias caracteristicas de las regiones geografico-botanicas de Mexico. An. Inst. Biol. Mexico. 8: 463-597. f. 1-74. 1937.
- O'Donell, C. A. Anatomia comparda del Leno de tres Simarubaceas Argentinas. Lilloa Rev. Bot. 1: 263–282. pl. 1–3. 1937.
- Orton, C. R. & Hill, L. M. Further observations on "bluestem" of potato. Am. Potato Jour. 15: 72-77. f. 1, 2. Mr 1938.
- Osterhout, W. J. V. Effects of potassium on the potential of *Halicystis*. Jour. Gen. Physiol. 21: 631–634. f. 1, 2. 20 My 1938.
- Over, W. H. Flora of South Dakota. 1-161. f. 1-82. Vermillion. Univ. So. Dakota. 1932.

- Pacca, D. W. Contribuicao ao estudo das doencas da Mandioca. Rodroguesia 3: 171-178. f. 1-9. S-D 1937.
- Parker, D. The Hepaticae of Indiana. Bryologist 41: 41-46.

 Ap 1938.
- Perez Moreau, R. A. Sinopsis de las Umbeliferas Argentinas del genero *Liloeopsis*. Lilloa Rev. Bot. 1: 283-306. pl. 1-8. 1937.
- Pilger, R. Drei neue arten von *Plantago* aus der Verwandtschaft von *P. pachyphylla* Gray. Repert. Spec. Nov. 40: 237–239. 30 Je 1936.
- Pittier, H. Clasificacion de los bosques. Bol. Soc. Venezolana Cien. Nat. 4: 93-110. S-O 1937.
- Pittier, H. Ensayo sobre la clasificacion de las especies Venezolanas del genero *Ficus*. Bol. Soc. Venezolana Cien. Nat. 4: 44-80. *illust*. S-O 1937.
- Poellnitz, K. von. Cotyledon sinus-Alexandri von Poellnitz spec. nov. Desert 10: 66-67. f. 1. Ap 1938.
- Polunin, N. Notes on a botanical journey in S. W. Greenland. 1937. Kew Bull. Misc. 1938: 89–98. 1938.
- Pomerleau, R. & Brunel, J. Inventaire discriptif de las flore mycologique du Quebec. II. Nat. Canadien. 65: 98-102. Mr 1938; III. 138-140. f. 7. Ap 1938.
- Porter, C. L. & Carter, J. C. Competition among fungi. Bot. Rev. 4: 165-182. Ap 1938.
- Prescott, G. W. Further notes on the desmids of Isle Royale, Michigan. The genus *Cosmarium*. Papers Michigan Acad. Sci. 23: 203-214. pl. 1-4. 1938.
- Pulle, A. Flora of Suriname (Netherlands Guyana) 1¹: 161-272. Ja 1938.
 - Kon. Kolon Inst. Amsterdam 30: Selaginellaceae, Lycopodiaceae contributed by A. H. G. Alston; Burmanniaceae by F. Jonker; Thurniaceae, Rapateaceae, Commelinaceae by H. Uittien; Eriocaulaceae, H. Uittien and A. N. J. Heyne; Xyridaceae, Typhaceae and Haemodoraceae by J. Landjouw; Lacistemaceae by G. Vaandrager and Olacaceae by G. J. H. Amshoff.
- Randolph, L. F. & Hand, D. B. Increase in vitamin A activity of corn caused by doubling the number of chromosomes. Science II. 87: 442-443. 13 My 1938.
- Ray, W. W. Some mushrooms, edible and poisonous. Cornell Agr. Exp. Sta. Bull. 386: 1-15. f. 1-13. Mr 1938.
- Reddick, D. & Mills, W. Building up virulence in *Phytophthora* infestans. Am. Potato Jour. 15: 29-34. F 1938.
- Rich, F. Notes on the flora of the Bermudas.—Freshwater algae from Bermuda. Jour. Bot. British & Foreign 76: 72-85. Mr 1938.

- Rick, J. Agarici Riograndenses. Lilloa Rev. Bot. 1: 307-346. 1937; 2: 251-316. 1938.
- Robbins, W. J. & Kavanagh, F. Vitamin B₁ or its intermediates and growth of certain fungi. Am. Jour. Bot. 25: 229-236. f. 1-8. Ap 1938.
- Roberts, E. A. & Haring, I. M. The water relations of the cell walls of certain mosses as a determing factor in their distribution. Ann. Bryol. 10: 97-114. f. 1-4. F 1938.
- Roberts, J. L. Evidence of a rotational growth factor in Bacillus mycoides. Science 87: 260-261. f. 1. 18 Mr 1938.
- Rogers, C. H. & Watkins, G. M. Strand formation in *Phymatotrichum omnivorum*. Am. Jour. Bot. 25: 244-246. f. 1-11. Ap 1938.
- Roivainen, H. & Bartram, E. B. Bryological investigations in Tierra del Fuego. Ann. Bot. Soc. Fennica Vanamo 9²: 1-58. f. 1-17. 1937.
- Rost, E. C. Burbank spineless Opuntia. Desert 10:23-24. illust. F 1938.
- Rountree, L. Some California violets. New Flora & Silva 10: 175–180. f. 55, 56. Ap 1938.
- Smith, W. M. Pollen spectrum of Lake Cicott bog, Cass County, Indiana. Butler Univ. Bot. Stud. 4: 43-54. f. 1. N 1937.
- Squire, F. A. & Briant, A. K. Spotting of bananas caused by *Frankliniella insularis*. (Franklin). Jour. Imp. Coll. Trop. Agr. 14: 351, 352. D 1937.
- Stahel, F. De *Cercospora* bladziekte der Bacoven. Dep. Landb. Suriname Bull. 53: 1–26. Ap. 1937.
- Standley, P. C. Notes upon woody plants of tropical America, with descriptions of two new species. Trop. Woods 52: 26-29. 1 D 1937.
- Standley, P. C. Studies of American plants. VIII. Field Mus. Nat. Hist. Bot. Ser. 17: 227-284. 10 D 1937.
- Stebbins, G. L. Critical notes on the genus *Ixeris*. Jour. Bot. 75: 43-51. F 1937.
- Stemen, T. R. & Myers, W. S. Oklahoma flora. i-xxix, 1-706. f. 1-494. Oklahoma City. Harlow Publ. Corp. 1937.
- Stevenson, F. J. & others. Breeding for resistance to late blight in the potato. Phytopathology 27: 1059-1070. f. 1, 2. N 1937.
- Steward, A. N. & Cheo, S. T. Recent botanical explorations in Kuangsi. China Jour. 23: 363-372. f. 1-39. D 1935.
- Stewart, W. D. & Arthur, J. M. Change in mineral composition of the tomato plant irradiated with a quartz-mercury vapor lamp and its relation to the level and ratio of calcium and phosphorus in the nutritive medium. Cont. Boyce Thompson Inst. 9: 105-120. f. 1. O-D 1937.

Svenson, H. K. Did Symphoricarpos albus come originally from Canada? Rhodora 39: 461, 462. N 1937.

Swallen, J. R. The grass genus Cathestecum. Jour. Washington Acad. Sci. 27: 495-501. 15 D 1937.

Taft, C. E. A new species of Vaucheria. Bull. Torrey Club. 64: 557. f. 1. N 1937.

Taubenhaus, J. J. & Altstatt, G. E. A decay of ornamental cacti caused by *Aspergillus alliaceus*. Mycologia 29: 681-685. f. 1. 1 D 1937.

Taylor, R. L. A western plant escapes in Virginia. Claytonia 4: 17-19. O 1937.

Thimann, K. V. & Sweeney, B. M. Action of auxin on protoplasmic streaming. Nature 140: 807, 808. 6 N 1937.

Thimann, K. V. & Sweeney, B. M. The effect of auxins upon protoplasmic streaming. Jour. Genl. Physiol. 21: 123-135. f. 1-7. 20 N 1937.

Thompkins, C. M. & Tucker, C. M. Foot rot of China-aster annual stock, and Transvaal daisy caused by *Phytophthora cryptogea*. Jour. Agr. Res. 55: 563-574. f. 1-4. 15 O 1937.

Tiffany, L. H. The filamentous algae of the west end of Lake Erie. Am. Midl. Nat. 18: 911-951. pl. 1-9. N 1937.

Tiffney, W. N. & Wolf, F. T. Achlya flagellata as a fish parasite. Jour. Elisha Mitchell Sci. Soc. 53: 298-300. D 1937.

Trelease, W. A Mexican puzzle (Yucca Howard-Smithii). Proc. Am. Philos. Soc. 78: 97-99. f. A-C. 22 O 1937.

Triana, J. Nuevos studios sobre las quinas. Rev. Acad. Colombiana 1: 257–275. pl. 1–3. 1937.

True, R. H. François Audré Michaux, the botanist and explorer. Proc. Am. Philos. Soc. 78: 313-327. 10 D 1937.

Truman, H. V. Fossil evidence of two prairie invasions of Wisconsin. Trans Wisconsin Acad. Sci. 30: 35-42. f. 1, 2. 1937.

Tukey, H. B. Plant parts of deciduous fruits which give evidence of being favorable for tissue culture. Proc. Nat. Acad. Sci. 23: 577-580. f. 1-4. 15 N 1937.

Tullis, E. C. Cercospora oryzae on rice in the United States. Phytopathology 27: 1005-1008. f. 1. O 1937.

Tysdal, H. M. & Westover, H. L. Alfalfa improvement. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 1122-1153. f. 1-12. 1937.

Uber, F. M. & Goodspeed, T. H. Microincineration studies III.

Shrinkage phenomena during carbonization and ashing of wood. Proc. Nat. Acad. Sci. 22:463-469. f. 1-4. 15 Au 1936.

Velasco, E. Hereditariedade da fórma da folha do algodoeiro. Rodriguesia 2: 197-202. 1936.

- Vickery, H. B., Pucher, G. W., Waksman, A. J. & Leavenworth, C. S. Chemical investigations of the tobacco plant.
 VI. Chemical changes that occur in leaves during culture in light and in darkness. Connecticut Agr. Exp. Sta. Bull. 339: 757-832. Au 1937.
- Vinall, H. N. & Hein, M. A. Breeding miscellaneous grasses. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 1032–1102. f. 1–26. 1937.
- Wade, B. L. Breeding and improvement of peas and beans. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 251–282. f.1 1937.
- Walker, J. C., Morell, S. & Foster, H. H. Toxicity of mustard oils and related sulfur compounds to certain fungi. Am. Jour. Bot. 24: 536-541. f. 1, 2. O 1937.
- Walther, E. Echeveria hybrids. Jour. Cactus & Succ. Soc. Am. 9:19-21. illust. Au 1937.
- Waltman, C. S. The seasonal course of soluble nitrogen and phosphate phosphorus in the shoot growth of Winesap apple and Elberta peach. Kentucky Agr. Exp. Sta. Bull. 367:159-191. O 1936.
- Waterman, A. M. New hosts and distribution of *Rehmiellopsis bohemica*. Phytopathology 27: 734-736. Je 1937.
- Watkins, G. M. Embryo-sac development in Yucca rupicola. Am. Jour. Bot. 24: 481-484. f. 1-21. O 1937.
- Weatherby, C. A. A further note on Salvinia. Am. Fern Jour. 27:98-102. Jl-S 1937.
- Weatherby, C. A. A list of varieties and forms of the ferns of eastern North America. Am. Fern. Jour. 27: 20-24. Ja-Mr; 51-56. Ap-Je 1937.
- Wehmeyer, L. E. Studies of certain species of *Melanconis* on *Carpinus*, *Ostrya* and *Corylus*. Mycologia 29: 599-617. f. 1-3. S-O 1937.
- Welch, W. H. Studies in Indiana bryophytes. Proc. Indiana Acad. Sci. 46: 72-78. f. 1-52. 1937.
- Wellman, F. L. Control of southern celery mosaic in Florida by removing weeds that serve as sources of mosaic infection. U. S. Dep. Agr. Tech. Bull. 548: 1-16. f. 1-4. F 1937.
- Wheeler, L. C. Berberis amplectans (Eastw.) comb. nov. Rhodora 39: 376. S 1937.
- Wherry, E. T. A hybrid-fern name and some new combinations. Am. Fern Jour. 27: 56-59. Ap-Je 1937.
- Whitaker, T. W. & Jagger, I. C. Breeding and improvement of cucurbits. U. S. Dep. Agr. Yearbook Agr. Res. 1937: 207–232. f. 1–7. 1937.

White, A. Opuntia names. Jour. Cactus & Succ. Soc. Am. 8:

175-176. illust. Ap 1937.

White, D. Fossil plants from the Stanley shale and Jackfork sandstone in southeastern Oklahoma and western Arkansas. U. S. Dep. Int. Prof. Paper 186-C: 43-67. pl. 10-14. 1937.

Whitehead, J. Some Arizona ferns collected in Sonora, Mexico. Am. Fern Jour. 27: 43-51. pl. 3. Ap-Je 1937.

Whitney, L. D. A new species of Garnotia from Rarotonga. Bernice P. Bishop Mus. Occ. Papers 13: 77-78. f. 1. 17 My 1937.

Wieland, G. R. Twenty-five years of paleobotany, 1910-1935. Brooklyn Bot. Memoirs 4: 87-95. pl. 1, 2+f. 1, 2. 7 My 1936.

Wiggins, I. L. Effects of the January freeze upon the Pitahaya in Arizona. Jour. Cactus & Succ. Soc. Am. 8: 171. Ap 1937.

Wiggins, I. L. & Stockwell, P. The maritime Franseria of the Pacific coast. Madroño 4: 119-120. 4 O 1937.

Preparation of plant growth-promoting sub-Wilcoxon, F. stances. I. 1-naphthaleneglyoxalic ethyl ester; 1-naphthaleneglycollic acid; 1-naphthaleneacetic acid. Contr. Boyce Thompson Inst. 8: 467-472. f. 1. Ap-Je 1937.

Wilder, W. B. Plant hunting on the Gaspé. House & Garden 715: 83, 100, 101. illust. My 1937; 716: 56, 109, 114. illust.

Je 1937.

Williams. L. O. Orchid Studies. II. Harvard Univ. Bot. Mus. Leafl. 5: 41-48. 19 O 1937; 49-60. 2 N 1937.

Willis, L. G. & Piland, J. R. A response of alfalfa to borax. Science II. 86: 179, 180. 20 Au 1937.

Willis, L. G. & Piland, J. R. Some recent observations on the use of minor elements in North Carolina agriculture. Soil Sci. 44: 251–262. pl. 1–3+f. 1. O 1937.

Wilson, E. E. The shot-hole disease of stone-fruit trees. Univ. California Agr. Exp. Sta. Bull. 608: 1-40. f. 1-13. Je 1937.

Wilson, J. D. & Runnels, H. A. The effect of various spray materials on tomato transplants. Ohio Agr. Exp. Sta. Bull. 22:58-65. f. 1-3. Mr-Ap 1937.

Wilson, P. W. & Fred, E. B. Mechanism of symbiotic nitrogen fixation. II. The pO. function. Proc. Nat. Acad. Sci. 23: 503-508. f. 1. S 1937.

Wilson, P. W. & Wagner, F. C. Combined nitrogen and the nitrogen fixation process in leguminous plants. Wisconsin Acad. Sci. 30: 43-50. 1937.

- Witmer, S. W. Morphology and cytology of Vallisneria spiralis L. Am. Midl. Nat. 18: 309-333. pl. 1-5. My 1937.
- Wolf, F.A. El mildew del tabaco de la Argentina y el de Australia y de los Estados Unidos. Revista Argentina Agron. 2: 14-16. Ap 1935.
- Woods, M. W. Meiotic studies in triploid *Tulipa* with special reference to bridging and fragmentation. Bot. Gaz. 99: 103-115. f. 1-31. 27 S 1937.
- Woods, M. W. The nucleolus in *Tulipa*. Am. Jour. Bot. 24: 528-536. pl. 1+f. 1-3. O 1937.
- Woodson, R. E. & Seibert, R. J. Contributions toward a flora of Panama I. Collections in the provinces of Chiriquí, Coclé, and Panama, by R. J. Seibert during the summer of 1935. Ann. Missouri Bot. Gard. 24: 175-210. pl. 5-8+f. 1. 30 Ap 1937.
- Wright, N. Pollination and the seediness of Marsh grapefruit. Proc. Agr. Soc. Trinidad & Tobago 37: 51-60. Ja-F-Mr 1937.
- Wulff, E. V. Essay of dividing the world into phytogeographical regions according to the numerical distribution of species. Bull. Appl. Bot. & Pl. Breed. I. 2: 315-368. illust. 1937.
- Wynd, F. L. Plants described originally from Crater Lake National Park. Madrono 3: 356-359. O 1936.
- Wynd, F. L. The flora of Crater Lake National Park. Am. Midl. Nat. 17: 881-949. N 1936.
- Wynd, F. L. The floral wealth of Crater Lake. Nat. Hist. 40: 419-427. illust. Je 1937.
- Yanovsky, E. Food plants of the North American Indians. U. S. Dept. Agr. Misc. Publ. 237: 1-83. Jl 1936.
- Yarwood, C. E. Physiologic races of snapdragon rust. Phytopathology 27: 113-115. f. 1. Ja 1937.
- Yarwood, C. E. The relation of light to the diurnal cycle of sporulation of certain downy mildews. Jour. Agr. Res. 54: 365-373. 1 Mr 1937.
- Yarwood, C. E. The tolerance of *Erysiphe Polygoni* and certain other powdery mildews to low humidity. Phytopathology 26: 845–859. S 1936.
- Yarwood, C. E. Unreported powdery mildews. Plant Disease Rep. 21: 180-182. f. 20. 1 Je 1937.
- Yeager, A. F. Studies on the inheritance and development of fruit size and shape in the tomato. Jour. Agr. Res. 55: 141-152. f. 1, 2. 15 Jl 1937.

- Yen, T. K. Floral development and vascular anatomy of the fruits of *Ribes aureum*. Bot. Gaz. 98: 105-120. f. 1-35. 30 S 1936.
- Yin, H. C. Effect of auxin on *Chlorella vulgaris*. Proc. Nat. Acad. Sci. 23: 174-176. f. 1. 15 Mr 1937.
- York, H. H., Wean, R. E. & Childs, T. W. Some results of investigations on *Polyporus Schweinitzii* Fr. Science II. 84: 160-161. 14 Au 1936.
- Young, R. A. Phyllostachys sulphurea var. viridis var. nov. and P. edulis (Carr.) H. de L. Jour Washington Acad Sci. 27: 343-349. 15 Au 1937.
- Yuncker, T. G. Observations on the teratology of the genus *Peperomia*. Bernice P. Bishop Mus. Occ. Papers 13: 5-9. f. 1, 2. 20 Mr 1937.
- Yuncker, T. G. Revision of the Polynesian species of Peperomia. Bernice P. Bishop Mus. Bull. 143: 1-73. f. 1-35. 1937.
- Yuncker, T. G. Three additional species of *Peperomia* in Hawaii. Bernice P. Bishop Mus. Occ. Papers 13: 161– 165. f. 1, 2. 15 Jl 1937.
- Zahniser, H. In March-André Michaux. Nature Mag. 29: 135. Mr 1937.
- Zaumeyer, W. J. & Kearns, C. W. The relation of aphids to the transmission of bean mosaic. Phytopathology 26: 614–629. Jl 1936.
- Zaumeyer, W. J. & Wade, B. L. Pea mosaic and its relation to other legume mosaic viruses. Jour. Agr. Res. 53: 161-185. f. 1-4. 1 Au 1936.
- Zaumeyer, W. J. & Wade, B. L. Varietal reaction of pea to pea-streak virus I. Phytopathology 27:1009-1013. O 1937.
- Zeller, S. M. Two Septoria leaf-spot diseases of Rubus in the United States. Phytopathology 27: 1000-1005. f. 1, 2. O 1937.
- Zimmerman, P. W. Growth-promoting substances. American Nurseryman 66⁴: 7, 8. illust. 15 Au 1937.
- Zimmerman, P. W. & Hitchcock, A. E. Comparative effectiveness of acids, esters, and salts as growth substances and methods of evaluating them. Contr. Boyce Thompson Inst. 8: 337–350. f. 1–4. Ja-Mr 1937.
- Zumstein, R. B. Fungus growth as affected by varying concentrations of salts. Proc. Indiana Acad. Sci. 46: 86, 87. 1937.
- Zundel, G. L. Miscellaneous notes on the Ustilaginales. Mycologia 29: 583-591. f. 1. S-O 1937.

DIRECTORY OF DEALERS

IN MATERIALS OF SCIENCE

The firms listed in this section represent reputable dealers in materials for the laboratory, library, greenhouse, field and garden.

Before you make your purchases consult these firms.

You are assured of courteous treatment and an ample discount.

Mention the BULLETIN

A Cordon's Hand Printing Press

For Sale, Very Reasonable

A complete press in perfect working order, suited for printing botanical field labels, herbarium labels, exhibition labels, annotation labels, tags, notices, circulars, leaflets, and pamphlets.

The press is operated by foot-pedal or with a motor.

Complete fonts of English and foreign type are also available in all standard sizes.

Address communications to:

DR. HAROLD N. MOLDENKE

New York Botanical Garden
Bronx Park (Fordham Branch P.O.)
New York City

Some Psilophytales from the Hamilton group in western New York¹

CHARLES B. READ (WITH PLATE 30)

INTRODUCTION

In the spring and early summer of 1936, Mr. Carl W. Mumm and the writer spent six weeks collecting fossil plants in the Devonian sections of western New York from Canandaigua Lake westward to Lake Erie in the vicinity of Buffalo. Particular attention was given to the thin, lenticular masses of iron pyrites which occur in many localities at the top of the Moscow shale of late Hamilton age and below the Genesee shale of early Genesee age. Because this ferruginous band has been regarded in the past as the thin western representative of the Tully limestone it is known as the Tully pyrites. In recent years it has been assigned to the Hamilton by Cooper and Williams (5). The general features of these beds are wellknown to geologists. They occur as lenses which may be 6 to 8 inches thick and have an areal extent of several hundred square feet. Upon close examination, the material is seen to consist of the pyritized remains of a varied, dwarfed marine fauna intermingled with rare fragments of fossil plants. Small quantities of calcium carbonate remain, but the fossils are largely infiltrated and replaced by the sulphide of iron which likewise acts as a cementing agent. Evidently the pyrites band marks a shoaling of the Devonian seas and probably development of shallow lagoons of small extent where the marine fauna lived under conditions which caused its dwarfing. Land vegetation must have been established in areas near enough so that occasional fragments could drift in and become entombed on the foul bottom where they were preserved by infiltration of iron sulphide.

For the most part, the plant fossils consist of bits of stems and petioles which, in some cases, were crushed before petrification. The flattened specimens are, of course, very difficult to work with. However, those which are uncrushed or only partly flattened in many cases reveal sufficient detail to permit morphological study. Owing to the opaque nature of the iron pyrites the sections must be cut and polished for study with reflected light rather than ground thin for transmitted light.

The majority of the specimens collected are yet unstudied, except in a very preliminary fashion. The flora is, however, of fair size for such an early one and promises to furnish considerable information bearing on the

¹ Published with the permission of the Director, Geological Survey, United States Department of the Interior.

[The Bulletin for November (65: 507-597) was issued November 1, 1938]

morphology of the Devonian plants. Two of the forms present are members of the Psilophytales and are extremely interesting—one because of the fact that it is the second record of the genus, which has been previously known only from Middle Devonian rocks in the Burdeck Basin, Queensland, Australia, and the other because of its possible bearing on the relationship of the Psilophytales and the early fernlike types.

There follow brief preliminary descriptions which point out the principal features of these forms.

PSILOPSIDA PSILOPHYTALES

ASTEROXYLEAE

Schizopodium mummii, n. sp.

In the suite of specimens collected in Gooding's Landing Ravine near Cottage City and a mile or so from the shore on the east side of Canandaigua Lake is a block carrying a fragment of a stem which is referable to the genus Schizopodium Harris (7), previously known only from a single specimen collected in rocks of Middle Devonian age in Australia. The general aspect of this plant, which has been named for Mr. C. W. Mumm of the Geological Survey, is seen in figures 1–3. It will be observed that the fossil consists of a stem fragment carrying a lobate stele roughly cross-shaped in outline but with the ends of the bars enlarged as a result of the formation of a sort of secondary xylem. Surrounding this stele are bits of parenchyma, but in general these outer tissues are very poorly preserved and provide little morphological information of value.

A more detailed examination of the xylem reveals the fact that this is for the most part clearly primary. There appears to be an enlarged area of this tissue towards the extremity of each arm. Apparently, these arms become complicated as a result of further splitting or fluting of the column, as is seen in figures 2 and 3. The position of the protoxylem is definitely mesarch, a feature which is particularly obvious in figure 1. The most striking feature of this fossil is the development of what appears at first glance to be secondary growth at the apices of the arms or lobes of the column of xylem. This regular radially directed xylem is seen at xr in figure 1 as well as in the other two figures taken at lower magnifications. The preservation of the outer tissues is unfortunately so poor that cambium, if originally present, cannot be seen.

In the very similar tissue observed in the Australian Schizopodium davidi, Harris was of the opinion that this is not a true secondary xylem, since he could find no trace of cambium even in well-preserved specimens. He was, rather, of the opinion that this was a sort of pseudo-secondary

xylem. In discussing the probable origin of this radially arranged wood which he regarded as intermediate between true secondary and primary xylem, he suggested that "the desmogen cells outside the protoxylem tend to divide radially, which is the one direction in which they can divide freely, while the inner desmogen cells divide irregularly" (7). Thus, the irregularly as well as the radially arranged xylem could have been developed.

As regards the pitting of the tracheids, in the small amount of material at hand it has been impossible to demonstrate this. In Schizopodium davidi the pitting was shown to be scalariform in the protoxylem and multiseriate-bordered in the metaxylem and the problematical secondary

growth.

Summarizing the information, Schizopodium mummii is known at present from a fragment which indicates a slender axis carrying a solid xylem strand cross-shaped in transverse section. Presumably, the phloem followed its contour. The apices of the lobes are marked by the occurrence of a somewhat radially arranged xylem presenting the appearance of being secondary. The exact nature of this tissue cannot be determined from this material owing to its poor preservation.

Schizopodium mummii appears to be quite closely related to S. davidi Harris (7). However, an important difference is seen in the definitely mesarch nature of the primary xylem (excluding the radially arranged tissue) in the American plant as opposed to the exarch condition in the Australian specimen. Comparisions, however, cannot be carried very

far at present owing to the fragmentary nature of the material.

The most interesting fact about this plant is its presence in Middle Devonian (Hamilton) strata of New York, some 9,000 miles from Queensland, Australia, where the only other known species of the genus is found, also in rocks of Middle Devonian age (7). This may be taken to indicate that the genus is widely distributed, and was a frequent type in the Devonian landscape. It seems almost certain that it will be found at numerous localities as the Devonian floras are more completely studied.

Locality.—Outcrop known locally as Tully pyrites at stream level in Goodings's Landing Ravine, 1 mile east of Gooding's Landing, Canan-

daigua Lake, New York.

ARACHNOXYLON n. gen.2

Characters at present are those of the only known species, which follows.

 $^{^2}$ From the Greek $\mathring{a}\rho \mathring{a}\chi \nu \eta$, spider, and $\xi \acute{v}\lambda o \nu$, wood, having reference to the outline of the xylem as seen in transverse section.

Aarchnoxylon kopfi (Arnold), n. comb.

Asteropteris kopfi Arnold, Buffalo Soc. Nat. Sci. Bull., 17 (1): 7-9, text fig. 2.

In 1935 Arnold described, under the name Asteropteris kopfi, a poorly preserved fragment of a small stem, the only illustration being a diagram. It is clear, however, from his description that he had in hand a specimen identical with the splendidly preserved stem in the writer's more recent collection from Canandaigua Lake. As will be shown at a later point, this species is not congeneric with Asteropteris Dawson and must be assigned to a new genus.

The general features of Arachnoxylon kopfi are shown in figure 4, which is a photograph, of a polished surface of a transverse section, magnified about 10 times. In the center is a highly fluted strand of xylem appearing as a many-armed, starlike figure. Near the apex of each of the protuberances is situated the mesarch protoxylem and a small island of parenchyma which usually is disorganized. The exact situation is perhaps made somewhat clearer by an examination of figure 5, which is a photograph taken at somewhat higher magnification. The protoxylem is centered around an area of what was apparently undifferentiated parenchyma forming a so-called loop. This is a structure which is rather characteristic of the early ferns.

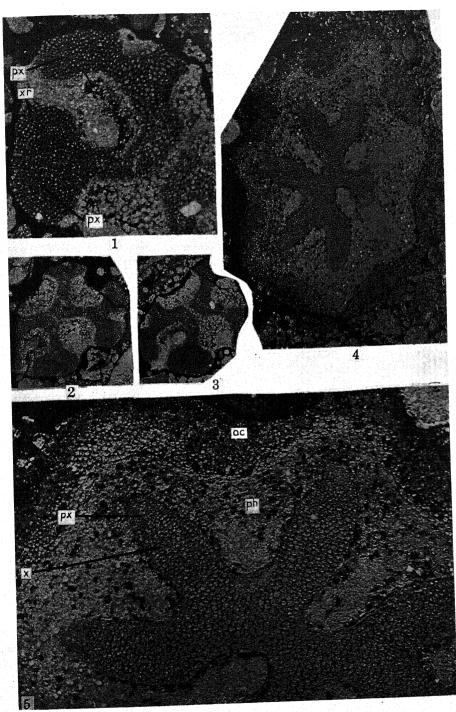
Sheathing the xylem is parenchyma which is probably referable to phloem, and which appears to follow the contour of the xylem in a general way, although there is much greater thickness in the reëntrants or bays than there is in the region of the apices. The dark spaces shown in this tissue are simply cavities or holes where the pyrites has been dragged from the interior of cells. In the oblique light used to illuminate the surface these, owing to the shadows which are cast, appear as dark cells suggesting gum-filled spaces. The details of this tissue cannot be made out, although its limits are clear.

On the exterior is small-celled parenchyma forming a zone of ap-

Explanation of Plate 30

Figs. 1-3. Schizopodium mummii n. sp. Figs. 2 and 3 transverse sections of the stem illustrating the lobed outline of the xylem and showing the enlarged apices of the arms $\times 10$; Fig. 1 a portion of a stem at a somewhat higher magnification showing the protoxylem (px), the metaxylem, and the radially directed xylem (xr), $\times 25$.

Figs. 4, 5. Arachnoxylon kopfi (Arnold) n. comb. Fig. 4 transverse section of the stem showing the stellate xylem, the problematical phloem, and the general relations of the tissues $\times 10$; Fig. 5 portion of the same section at a higher magnification, (x) the metaxylem, (px) the protoxylem, (ph) the problematical phloem, (oc) the cortex, $\times 25$.



READ: PSILOPHYTALES

preciable width and extending outward as far as the present limits of the specimen. This is probably cortex and extends just under the epidermis.

Noteworthy is the fact that there are no vascular strands given off by the stem stele and passing out into leaves. It is, of course, possible that there may have been scale leaves, but there is no evidence of any larger leaves with vascular tissue.

In summary, then, the stem of *Arachnoxylon kopfi* presents the following features:

- 1. A stele stellate in transverse section with a solid xylem and sinuous xylem arms. In other words, it is a highly fluted column. The xylem is mesarch, a protoxylem group being situated at the apex of each arm. An island of parenchyma occupies the middle of each protoxylem group. The phloem follows the xylem contours but fills to a greater extent the bays than the points, thus making less prominent the fluted nature of the stele.
- 2. On the exterior is a small-celled parenchyma extending to the outer edge of preserved material.
- 3. Leaf traces or other vascular strands are not known to depart from the stele, and there is no evidence of leaves of any sort existing. Branching is unknown.

From the above description it is evident that the New York fossil approaches representatives of the genus Asteroxylon in general organization. Both have a stellate xylem, and the zone of phloem is similar in both cases. In the known species of Asteroxylon (8, 9, 10) the protoxylem is slightly immersed but does not form the prominent loops that are seen in Arachnoxylon kopfi. It is impossible to compare the leaves or scalelike emergences in the two since there is no evidence of such structures in A. kopfi. The great difference between Asteroxylon and Arachnoxylon is the presence of the mesarch protoxylem and the parenchymatous island or peripheral loop in the apex of each arm in the latter, as opposed to the very simple, slightly immersed protoxylem area in Asteroxylon. Examination of the material also gives the impression that there is more of a fixity in the stellar form in Arachnoxylon then in the Asteroxylon. In the writer's opinion the presence of this "peripheral loop" is a matter of considerable importance.

The reasons for removing the fossil under discussion from Asteropteris Dawson are rather obvious. The two are quite different. Asteropteris novaboracensis (3, 6), the only known species, is a siphonostelic stellate type which shows evidences of whorls of phyllophores. The features of both stem and phyllophore trace indicate its inclusion in the Zygopteridaceae. Apart from the occurrence of "peripheral loops" in the arms of both there is no more than a very general similarity of stelar form.

This fossil, Arachnoxylon kopfi, seems to represent a very important morphological type among Devonian plants. From the viewpoint of stem structure it is rather close to what might be considered the fern prototype. It is a nonmedullated stellate type, a protostele approaching in form the stellate steles of the Devonian and Carboniferous Zygopterideae, such as Asteropteris novaboracensis Dawson, Ankyropteris grayi (Williamson) Scott, Ankyropteris henricksi Read, Austroclepsis osborni Sahni, and Asteroclaena laxa Stenzel. The protoxylem, it will be recalled, is situated around the "peripheral loops" of undifferentiated parenchyma in these ferns and presents an appearance identical to the mesarch condition observed in Arachnoxylon. The writer is of the opinion that this is an indication of real relationship. It is true that the zone interpreted as phloem is quite broad in the New York plant as compared with the similar tissue in the Zygopterideae. However, this is only a matter of detail and could readily have been modified. With increase in size such a plant type might readily have developed a parenchymatous central area in the stele constituting a mixed or true pith. And from the dichotomous or lateral branches of such a type one might expect to develop the primitive tetrastichous phyllophore which is characteristic of Asteropteris novaboracensis or the structure typical of Stauropteris (1, 2), the earliest members of the Zygopterideae whose stelar morphology is well-known.

In short, the writer suggests that such a type as Arachnoxylon kopfi may be regarded as morphologically close to the psilophytalean ancestor from which the Paleozoic fern types were derived. The peripheral loop points to a certain amount of relationship between the Zygopterideae and the fossil described above. From such stelar type the phyllophore of the Stauropteris or Asteropteris type could have readily been derived as a result of branching.

It is likewise probable that from a type showing the structural features of this plant the Cladoxyleae were derived as a result of stelar branching, resulting in the so-called polystelic condition, a factor related to increase in size, and at the same time modification of lateral branches into megaphylls. This group, the Cladoxyleae, still is problematical, although Bertrand (4) has gone far toward its elucidation. In his opinion its affinities lie with the ferns.

Locality.—Outcrop known locally as Tully pyrites at stream level in Gooding's Landing Ravine, 1 mile east of Gooding's Landing, Canandaigua Lake, New York.

SUMMARY

1. Two representatives of the Psilophytales are described from the

1. 63.

upper Middle Devonian of western New York. These are Schizopodium mummii n. sp., and Arachnoxylon kopfi (Arnold) n. comb.

- 2. Schizopodium mummii is a stellate type showing a small amount of radially arranged, secondary-like xylem at the apex of each arm. The type specimen is only a fragment. This fossil is the second known occurrence of the genus, the other station being in Queensland, Australia, in rocks of approximately the same age as those in which S. mummii occurs.
- 3. Arachnoxylon kopfi (Arnold) n. comb., is a form resembling known representatives of the genus Asteroxylon. It differs in its more robust aspect and in the presence of loops or islands of parenchyma around which is located the protoxylem near the apex of each arm. The phloem loosely follows the contour of the xylem, and outside is a zone of parenchyma. Appendages, and branches are unknown.
- 4. It is suggested that from a plant showing stem structure similar to Arachnoxylon the early fern types such as the Zygopterideae and the Cladoxyleae may have been derived. The writer is inclined to regard this form as highly organized representative of the Psilophytales "on its way towards becoming a fern."

Literature cited

- 1. Bertrand, Paul. 1909. Études sur la fronde des zygopteridées, pp. 1.286, pls. 1-16, Lille.
- 2. Bertrand, Paul. 1911. L'étude anatomique des Fougères anciennes et les problèmes qu'elle soulève; Progressus Rei Botanicae, 4: 215-281.
- 3. Bertrand, Paul. 1914. Étude du stipe de l'Asteropteris noveboracensis; Comptes Rendus, 12th Session International Geol. Congress, pp. 909-924
- 4. Bertrand, Paul. 1935. Contribution à l'étude des Cladoxylées de Saalfeld, Paleontographica, 80, Abt. B, lief 5-6: 101-170, 25 plates.
- 5. Cooper, G. A., and Williams, J. S. 1935. Tully formation of New York; Geol. Soc. America Bull. 46 (5): 781-868.
- 6. Dawson, J. W. 1881. Notes on new Erian (Devonian) plants; Geol. Soc. London Quart. Jour. 37: 299-308, pls. 12, 13.
- 7. Harris, T. M. 1929. Schizopodium davidi, gen. et. sp. nov., a new type of stem from the Devonian rocks of Australia; Royal Soc. London Philos. Trans., ser. B, 217: 395-410, pls. 91-93.
- 8. Kidston, Robert, and Lang, W. H. 1920. On Old Red Sandstone plants showing structure from the Rhynie chert bed, Aberdeenshire, Pt. 3, Asteroxylon mackiei Kidston & Lang; Royal Soc. Edinburgh Trans. 52, pt. 3 (No. 26): 643-680, pls. 1-17.
- 9. Kräusel, R., and Weyland, H. 1923. Beiträge zur Kenntnis der Devonflora; Senckenbergiana, 5, heft 5, 6: 154.
- 10. Kräusel, R., and Weyland, H. 1926. Beiträge zur Kenntnis der Devonflora II; Abh. Senckberg. Naturf. Gesell. 40, heft 2, 111-155, pls. 3-17.

Notes on plants of the Pacific Islands. I.

F. R. Fosberg

To record miscellaneous and fragmentary observations accumulated while studying and determining plants from various islands of the Pacific it seems worth while to start a series of papers, to appear at irregular intervals as sufficient material accumulates. The first of these is presented here, treating species of the genera *Gouania* (Rhamnaceae), *Diospyros* (Ebenaceae), and *Randia* (Rubiaceae).

Thanks are due to the authorities and staff of the New York Botanical Garden for the privilege of working in the herbarium and for various courtesies extended to me while working there, and also to the authorities of the Bernice Pauahi Bishop Museum, of Honolulu, for the loan of some of the specimens treated in this paper.

GOUANIA

Gouania mangarevica Fosberg, n. sp. Frutex scandens hirsutus vel tomentosus, folia dimorpha piloso-hirsuta supra bullata serrata membranacea vel chartacea, flores in spicas glomerata, spicae maxime 12 cm. longae, bracteoli minuti caduci, flores maxime 3 mm. latae pentamerae, styli 3, discus sub stylis barbatus in lobos triangulares productus.

Liane 20 m. or more long, older parts woody, younger parts hirsute-pilose with tawny spreading hairs, older parts becoming rusty-tomentose; leaves alternate, dimorphic, sparsely hirsute-pilose on both sides, especially beneath on the veins, bullate above, those on young sterile parts of the plants oblong or oblong-ovate, up to 9 cm. long and 4 cm. wide, truncate at base, acuminate at apex, coarsely serrate, especially above, membranous, those on older parts broadly ovate- or elliptic-cordate, obtuse to acuminate, usually shorter than those on sterile branches, as much as 6 cm. wide, chartaceous; tendril-bearing branchlets in the axils of the leaves, these sometimes bearing one or two small leaves, the tendrils slender on young branches but becoming much thickened and woody on the older parts, 2-3 tendrils borne on one branchlet, on older parts these branchlets more robust, sometimes occurring 2 at one node, bearing the inflorescences as well as tendrils. Inflorescence densely yellowishtomentose, spicate; spikes as much as 12 cm. long, often borne as many as 6 on a branchlet, forming a panicle; glomerules small, subtended by minute caducous bractlets, often scarcely manifest; flowers usually sessile, rarely short-pedicelled, pentamerous, about 3 mm. across when spread out; calyx tomentose externally, its lobes ovate, 1 mm. long, obtuse, glabrous within; petals alternate with the calyx lobes, clawed at the base, about 1 mm. long, the limb suborbicular, saccate, surrounding the upper part of the stamen; stamens opposite and almost equalling the petals; filaments flat, dilated toward the base, inserted beneath the disk between its lobes; anthers almost circular, 0.2–0.3 mm. long, the anther sacs terete; disk thin, produced into triangular lobes with strap-shaped apices, opposite the calyx lobes and two-thirds their length, glabrous except for a conspicuous tuft of hair immediately below the styles; styles 3, distinct to the base, divergent, glabrous, fleshy, about 0.7 mm. long; ovary inferior but indistinct in flower; fruit unknown.

Gambier Islands, Mangareva: South side Mt. Mokoto, upper forest' climbing over bushes and trees, alt. 320 m., June 2, 1934, St. John 14844 (type) (B); northwest slope Mt. Duff, in woods on low bushes, alt. 110 m., May 24, 1934, St. John 14488. (B).

Mangarevan name "tara koa" (acc. Theophile, a native informant).

This species seems to resemble most closely the widespread Indo-Malaysian G. tiliaefolia and G. javanica and also certain similar American species but differs from all in the dimorphic leaves and in the tuft of hair surrounding the styles. This whole group of species of Gouania badly needs revision. Perhaps all might be united into one large species with many varieties, as they closely resemble each other. However, certain details in the formation and hairiness of the disk, and especially in the length and degree of union of the styles seem significant. All specimens of G. tiliaefolia and G. javanica examined except one had very short styles. Most of them had more prominent bracts and less paniculate inflorescences than G. mangarevica. More distantly related are G. vitifolia of Hawaii, with shorter spikes and quite different leaves, and G. Richii of Fiji, with almost glabrous leaves and with the styles united part way up.

Hooker and Arnott (Bot. Beechey Voy. 61, 1832) report Gouania dominguensis L., an American species, from the Society Islands, citing a Lay and Collie collection, and many subsequent authors have credited the species to these islands, presumably on the basis of this report. To my knowledge no other collection has been cited. The authorities at Kew are unable to locate this Lay and Collie specimen, so its identity may not be determined. However, remembering that Hooker and Arnott regarded most of southeastern Polynesia as included in the Society Islands, and since no other Gouania has been found in southeastern Polynesia, I think it quite probable that the Lay and Collie specimen belonged to G. mangarevica. The expedition spent some time in Mangareva and is known to have collected several other plants there. It is unlikely that it was an American species, unless there was a confusion in labeling, as with several other plants collected by this expedition.

Fruiting specimens are much to be desired.

DIOSPYROS

While working up the Hawaiian species of Diospyros I found it neces-

sary to determine the status of the Maba sandwicensis reported by Seemann and subsequent authors from Fiji. This did not prove as easy to settle as was expected, and led to a considerable study of various Pacific Ebenaceae, and comparison with available Malaysian and Asiatic material. No attempt was made at a revision of the Pacific species of this group, but some observations were made which seem worth recording. The specimens studied are mainly in the herbaria of the New York Botanical Garden and the Bishop Museum, designated here respectively as (N) and (B). Dates of collections are not cited when collectors' numbers are available.

The recent study of the Malaysian Ebenaceae by R. C. Bakhuizen van den Brink (Bull. Jard. Bot. Buit. ser. 3, XV¹, 1936; XV², 1937) treats some of the Pacific species and makes the combinations for several of them under Diospyros, but touches upon the extra-Malaysian ones only incidentally. Bakhuizen's reasoning (Gard. Bull. Str. Sett. 7, pt. 2, 1933) in reducing Maba to Diospyros seems, in the light of these further studies of Pacific species, to be thoroughly sound, and necessitates the transfer of several Pacific island species from Maba to Diospyros. Other transfers are doubtless to be made, but material has not been available to determine their exact status.

Diospyros subgen. Maba sect. Ferreola

Diospyros L. subgen. Maba (Forst.) Bakh sect. Ferreola (Roxb.) Fosberg, n. comb.

Ferreola Roxb. Pl. Corom. 1: 35, t. 45, 1795.

Maba sect. Ferreola Hiern, Trans. Cambr. Philos. Soc. 12: 108, 1873. Diospyros subgen. Maba sect. Forsteria Bakh. Bull. Jard. Bot. Buit. ser. 3, XV²: 50, 1937.

Hiern's name Ferreola, based on Roxburgh's genus Ferreola (credited to Koenig by Index Kewensis), seems to be the earliest to have been used in the sectional category for this group of species, and so by the rule of priority must replace Forsteria. It may be argued that Hiern's section of Maba was more inclusive than Bakhuizen's section of Diospyros, but the type species of Roxburgh's genus was Ferreola buxifolia (Diospyros ferrea) which was also included in Hiern's section Ferreola and is the principal species of Bakhuizen's section Forsteria, though no type species was designated. This seems to make all three nomenclatorially equivalent, and therefore the earliest name must take precedence.

The present studies show that there are at least five distinct species belonging to this section, and a number of additional varieties in the two original species.

Diospyros ferrea (Willd.) Bakh., var. nandarivatensis (Gillespie) Fosberg, n. comb.

Maba nandarivatensis Gillespie, Bish. Mus. Bull. 74: 13, 1930.

Bakhuizen reduces this species outright to *D. ferrea* var. sandwicensis, but it seems to me to present differences enough to be maintained as a variety. The leaf-shape is not that of var. sandwicensis and the fruit is more nearly that of var. littorea. The branched inflorescence (in the staminate plant as shown by Smith 544 as well as in the pistillate as described by Gillespie) suggests that it may have some relationship with *D. ellipticifolia*, and, indeed, except for the small size of the fruit, might equally well be placed in the latter. It certainly connects the two.

As recognized here, the size of the leaves and fruits varies considerably, but there seems no place to draw a line between them. Those with large leaves tend to have large fruits, but this is not constant.

Specimens examined:

Fiji Is.: Viti Levu, Tholo North Prov., Nandarivatu, Gillespie 3764 (N); Vanua Levu, Thakaundrove, Natewa Peninsula, Uluingala, Smith 1982 (N); Vanua Levu, Thakaundrove-Malhuata boundary, crest of Korotini Range, bet. Navitho Pass and Mt. Ndelaikoro, Smith 544 (N); Vanua Levu, Mbua, southern portion of Seatovo Range, Smith 1564 (N); Kandavu, hills above Namalata and Ngaloa bays, Smith 126 (N).

CAROLINE Is.: Yap, Kanehira 11840 (N).

PALAU Is.: small islands near Korror, Herre 29 and 36 (N).

The last four collections cited have much larger leaves than the first four.

Diospyros ferrea (Willd.) Bakh., var. Gillespiei Fosberg, n. var.

Ramuli glabrati; folia coriacea elliptica vel oblonga subsessilia canaliculata, nervis supra impressis; fructus subsessilis 1.5–2 cm. longus; calix in fructu glaber.

Branches and branchlets gray, beset with prominent lenticels, strigose when very young, but early glabrate; leaves stiff-coriaceous, elliptical to oblong, subsessile, canaliculate, the veins prominently impressed above, the blade up to 8 cm. long and 3.5 cm. wide, glossy, minutely appressed puberulent when very young, but soon becoming glabrate; flowers not seen; fruits subsessile, cylindric to ellipsoidal, sparsely appressed hirtellous, 1.5–2 cm. long, tipped with the persistent style; fruiting calyx cupulate, 7–8 mm. across, its lobes rounded to obtuse, low, glabrous inside, glabrous or almost so outside.

FIJI Is.: Viti Levu, Naitasiri Province, woods near road beyond Tamavia village, $7\frac{1}{2}$ mi. from Suva, alt. 150 m., Gillespie 2450 (B, N); same loc., Gillespie 2146 (B), (type).

Referred by Gillespie to Maba sandwicensis, by A. C. Smith to Maba buxifolia, and by Bakhuizen to Diospyros ferrea var. littorea.

Diospyros ferrea (Willd.) Bakh., var. subimpressa Fosberg, n. var.

Ramuli glabrati; folia coriacea elliptica glabrata, nervis supra subimpressis; fructus ovoideus vel ovalis strigosus, calix in fructu planus vel reflexus strigosus.

Branches brownish, beset with prominent lenticels, sparsely strigose when young, glabrate; leaves stiffly coriaceous, elliptical, acute at base, rounded-acute at apex, sparsely strigose beneath when young, glabrate, the veins somewhat impressed above, the petiole about 2.5 mm. long; flowers not seen; fruits solitary on peduncles 2 mm. or less long, ovoid to broadly oval, up to 15 mm. long and 13 mm. wide, tipped with the persistent style, rather persistently strigose; fruiting calyx flat or with lobes reflexed, about 7 mm. wide, the lobes low, obtuse, strigose inside and outside.

Fiji Is.: Viti Levu, Rewa Province, woods near summit of Korombamba mountain, Gillespie 2324 (B), (type).

Very close to var. *Gillespiei*, differing chiefly in the shape of the fruit and in the less conspicuously impressed veins. Referred to *Maba sandwicensis* by Gillespie.

Diospyros ferrea (Willd.) Bakh., var. savaiiensis (Christ.) Fosberg, n. comb.

Maba savaiiensis Christophersen, Bish. Mus. Bull. 128: 173, 1935.

Characterized by coriaceous leaves, reticulate on both sides, abruptly contracted, then shortly attenuate into a petiole, blade ovate-acute, fruiting calyx reflexed, appressed puberulent inside and out, and fruit appressed puberulent. Plant otherwise glabrous or very early glabrate.

SAMOA: Savaii, Falealupo-Fagalele, Christophersen 3328 (N).

Diospyros ferrea (Willd.) Bakh., var. angustifolia (Miq.) Bakh.

Schlechter 19205 from "Walder bei Alexishafen, Kaiser-Wilhelmsland" (N) is, so far as I know, the first record of this variety from New Guinea. It agrees well with material of this variety (Thwaites; DeSilva 43 from Ceylon (N), cited by Bakhuizen. The other two specimens cited by him, Stocks from Malabar Concan (N) and Kajewski 932 from the New Hebrides (N) do not agree so well, and probably do not belong to this variety.

Diospyros ellipticifolia (Stokes) Bakh., var. elliptica (Forst.) Fosberg, n. comb.

Maba elliptica Forst. Char. Gen. Pl. 122, t. 61, 1776. Ferreola ellipticifolia Stokes, Mat. Med. 535, 1812.

This, the typical form with elliptic obtuse leaves, dull and venulose above, may be reported, I think for the first time, from Niuafou, (Jaggar, Oct. 1930, (B)).

This variety is widespread from Samoa to Malaysia and southeastern

Asia. Specimens were examined from Samoa, New Caledonia, and Amboina (all N). Forster's original material came from Tonga.

Diospyros ellipticifolia (Stokes) Bakh., var. iridea Fosberg, n. var. Maba aff. elliptica Christophersen, Bish. Mus. Bull. 128: 173, 1935.

Arbor, ramuli aureo-sericei glabrati; folia lanceolata; flores paniculatae; fructus 23-25 mm. longus leviter umbonatus; calix in fructu cupulatus glabratus.

Tree 6 m. tall, branches terete, grayish brown, rather smooth; leaves not congested; young parts at first golden-sericeous, very early glabrate; leaves lanceolate, slightly acuminate, blunt, up to 11 cm. long and 3 cm. wide, chartaceous, glossy, drying an almost iridescent gray-brown, the petiole 3–5 mm. long; staminate flowers in loose 4–5 flowered panicles about 10–13 mm. long, panicle and calyx densely sericeous; calyx tube 2 mm. long, lobes 1 mm., acuminate; corolla tube cylindrical, 4 mm. long, 1 mm. wide, sericeous just beneath the lobes, otherwise glabrous, lobes ovate, 1 mm. long, sericeous; pistillate flowers not known; fruit on a peduncle 1 cm. long, red when ripe, yellow when immature, 23–25 mm. long, 15 mm. wide, slightly umbonate at apex; fruiting calyx glabrate, cupulate, 7–8 mm. across, lobes obtuse.

SAMOA: SAVAII, near Tufutafoe, alt. 10 m., Christophersen 2272 (B, N), 3310 (B, N) (type); (type sheet B). No. 2272 is in flower and no. 3310 in fruit.

Differs from var. *elliptica* in the shiny thin lanceolate leaves, light colored smooth twigs, acuminate calyx lobes, pedicellate flowers, much smaller calyx and corolla, and red fruit.

Diospyros lateriflora (Hiern) Bakh.

This species may be reported from Uvea on the basis of Burrows W. 23 "inland, edge of forest, el. 15 m." (B). Burrows gives the aboriginal name as mapa. This specimen was labeled Maba sandwicensis in the herbarium. Parks, 16291 from Liku Terrace, Eua, Tonga Is. (N) and a collection from Tonga, without island or locality, McKern 99 (B), also belong to this species.

Some doubt was expressed by Bakhuizen in assigning this species to his section *Forsteria*. The material at hand shows that the ovary is definitely 3-celled, the cells 2-ovuled, the ovary hairy, the style trifid, and staminodia absent; seeds were not available, so the endosperm could not be examined. There seems little doubt that it belongs in this section, here called *Ferreola*.

Diospyros globosa (A. C. Smith) Fosberg, n. comb.

Maba globosa A. C. Smith, Bish. Mus. Bull. 141: 121, 1936.

This is close to *D. lateriflora*, as Smith says. It may eventually prove only a variety, if further collecting should reveal intergrades, as the differences are no greater than the extremes in *D. ferrea* and *D. ellipticifolia*.

Material now available does not justify any change in its status, other than the generic transfer.

The fruits on *Smith 1242* are not mature and would probably approach in size those of *D. lateriflora* at maturity.

Fiji Is.: Kambara, Smith 1241 (isotype), 1242 (both N).

Diospyros Christophersenii Fosberg, n. name

Maba samoensis Hiern, Jour. Bot. 15: 99, pl. 186, 1877.

Not Diospyros samoensis Gray.

Amply characterized by Hiern. Known only in fruit. Probably to be placed in sect. *Ferreola*, though in absence of flowering specimens this is uncertain.

SAMOA: Savaii, Siuvao-Auala, Christophersen 3379 (N).

Diospyros subg. Maba sect. Cupulifera

Diospyros L. subgen. Maba (Forst.) Bakh. sect. Cupulifera Fosberg, n. sect. Calix in fructu insigniter accrescens, fructum usque ad medium cingens. Fruiting calyx extremely accrescent, woody, surrounding the lower half of the fruit; ovary trilocular; fruit and calyx copiously rusty pubescent.

Diospyros rufa, characterized by its peculiar acorn-like fruit, was placed in Maba sect. Ferreola by Hiern, and would go, according to Bakhuizen's key, into sect. Forsteria, but seems to have little in common with the rest of the members of the section. Those who follow a narrow genus concept would doubtless refuse to include them in the same genus. So far as I know, the type species, D. rufa, in the sense accepted below, is the only species in the section described above.

Diospyros rufa (Labill.) Fosberg, n. comb.

Maba rufa Labill. Sert. Austr. Caled. 33, t. 36, 1824.

Maba sericocarpa F. Muell. Fragm. 5: 164, 1866.

Maba cupulosa F. Muell. Fragm. 5: 164, 1866.

Diospyros sericocarpa F. Muell. Austr. Veg. in Intercol. Exh. Ess. 1866-67: 35, 1867.

Diospyros cupulosa F. Muell. Austr. Veg. in Intercol. Exh. Ess. 1866-67: 35, 1867.

Maba yaouhensis Schlecht., Engl. Bot. Jahrb. 39: 226, 1906.

? Maba parviflora Schlecht., Engl. Bot. Jahrb. 39: 226, 1906.

Material of this species from New Caledonia has generally broader and more obtuse leaves than that from Australia.

Schlechter's species cannot, on the basis of material available, be maintained as specifically distinct. The small flowers of the material upon which *M. parviflora* was based suggest that if more material were available it might prove to be a good variety.

RANDIA

Randia cochinchinensis (Lour.) Merr. Tr. Am. Phil. Soc. 24 (2): 365, 1935.

Aidia cochinchinensis Lour. Fl. Cochinch. 143: 1790.

Stylocoryne coffeoides Gray, Proc. Am. Acad. 4: 309, 1860 (excl. syn.).

Randia coffeoides (Gray) B. & H. Gen. Pl. 2:88, 1873.

Randia Graeffei Reineke, Engl. Bot. Jahrb. 25: 683, 1898.

Full synonymy in Merrill, Tr. Am. Phil. Soc. 24(2): 365, 1935.

The widespread Pacific Randia coffeoides does not seem to differ significantly from the above tropical Asiatic and Malaysian species. Plants from Polynesia and Micronesia tend to have the buds slightly bent and sharper at the apex than most Asiatic specimens, but some, even from Ceylon, cannot be distinguished from those from the Pacific. Neither can I distinguish R. Graeffei on the basis of the description and a number of collections from Samoa. I have not seen the type. It is considered by Kanehira (Bot. Mag. Tokyo 45: 349, 1931) to be a synonym of R. racemosa (Cav.) F.-Vill., itself a synonym of R. cochinchinensis.

Stylocoryne coffeoides Gray was so inadequately characterized that it is doubtful whether it could be considered validly published. Neither specimens nor localities were cited, and both synonyms given by Gray have been shown by Seemann (Fl. Vit. 123) to belong to other genera altogether. The U. S. Exploring Expedition specimens and a collection by Harvey labeled by Gray are the only means of positive identification of the species. Duplicates of these that I have seen in the herbarium of the New York Botanical Garden are certainly R. cochinchinensis. Seemann (l.c.) considered these identical with Stylocoryne racemosa Cav. which Gray definitely excluded from his species. Merrill (l.c.) considers S. racemosa Cav., of the Philippines, to be a synonym of R. cochinchinensis. This seems to add the weight of Seemann's opinion to my reduction of R. coffeoides to R. cochinchinensis.

The range of the species in the Pacific extends from the Society Islands westward through most of the major island groups to Malaysia, and beyond through tropical Asia. It has been collected from most of the high island groups including the Societies, Samoa, Wallis, Fiji, Tonga, New Hebrides, Solomons, Marianas, Carolines, Palau, etc. It does not occur in the Hawaiian Islands, and has not been collected in the Cook Islands or the Marquesas, and, strangely enough, apparently not in New Caledonia. It may here be reported from the island of Niuafou on the basis of a specimen in the Bishop Museum collected by T. Jaggar, Oct. 1930.

BOTANY DEPT.,

University of Pennsylvania Philadelphia, Pa.

Studies on Rhizophidium II. Rhizophidium laterale

J. S. KARLING (WITH PLATE 31)

Rhizophidium laterale (Braun) Rabenk. is one of the earliest known chytrid species which was first described and figured by Braun (1855) on healthy and dead cells of Ulothrix zonata in Germany. He placed it in the subgenus Phylyctidium because of its unbranched knob and peg-like haustorial or absorbing system, and most investigators since that time have retained it in this group. In 1868, however, Rabenhorst transferred it to Schenk's (1858b) new genus Rhizophidium, where it was retained by Fischer (1892). It has subsequently been reported to occur on U. zonata and Mougeotia sp. in Germany (Schenk, 1858a, 1858b), Stigeoclonium sp., and U. zonata in Russia (Sorokin, 1883, 1889; Serbinow, 1907), and Spirogyra sp., in New York, U. S. A. (Sparrow, 1932). During the early summer of 1938 I found it in great abundance on *U. zonata* in Candlewood Lake, Connecticut, and my studies have brought to light certain structural characters and other data which necessitate the transfer of this species to Rhizophidium, as this genus is now recognized, and cast considerable doubt on the claim that it is ubiquitous as to host range.

HOST RANGE

Shortly after this chytrid had been brought into the laboratory, experiments were begun to determine its host range. These tests involved killed as well as living cells of Hydrodictyon reticulatum, Spirogyra crassa, Spirogyra sp., Stigeoclonium tenue, Draparnaldia sp., Nitella flexilis, Chara coronata, pollen grains of Pinus austriaca var. nigra, P. sylvestris, P. densiflora, P. banksiana, P. Thunberghii, and hemlock, ova of Fasciola hepatica and root tips of Allium cepa. The living cells and tissues were carefully examined and washed several times in sterile charcoal water, while the dead ones were transferred directly from the boiling water and dry heat oven in which they had been killed. These were then added to Petri dishes containing heavily infected filaments of U. zonata, placed in a cool place in front of an east window, and examined daily. As a check on whether or not these laboratory conditions were favorable and conducive to infection living and dead filaments of the algae listed above as well as onion root tips were tied up in small gauze bags and staked out in Candlewood Lake where the infected Ulothrix was growing.

The results of these laboratory and outdoor experiments were all negative. No infection of either the living or dead hosts has been observed

up to the present time. It is to be further noted that Stigeoclonium tenue, Oedogonium sp., Cladophora glomerata, and Spirogyra sp. were growing together with the infected Ulothrix in Candlewood Lake, and these were likewise free of infection. While these results and observations are somewhat limited and do not entirely preclude the possibility that R. laterale may occasionally infect other algae, they none the less suggest very strongly that it is limited to one host species.

The effect of *R. laterale* on the host cell is not always very marked, and it is often difficult to determine the degree of pathogenicity. Infected cells have been found whose protoplasm did not appear to be affected at all (fig. 1f), while others seemed to be distinctly injured. In the latter cases the chloroplasts gradually turn yellowish brown and begin to degenerate and eventually appear clumped with the starch grains, other granules, and the remainder of the protoplasm around the delicate rhizoidal strands, as is shown in figure 1a and 1b. In a few instances zoospores have been found germinating on dead cells and developing into mature thalli, which indicates that this chytrid may also be saprophytic. This is further borne out by my limited success in infecting killed *Ulothrix* filaments, as will be noted later.

STRUCTURE OF THE THALLUS

The development of this species has been briefly but well treated by Braun, and I shall confine my description largely to certain structural characters and developmental phases which have not yet been emphasized. Rhizophidium laterale is frequently gregarious, as is shown in figure 1, and in very exceptional cases as many as twelve thalli have been found on a single cell. A heavily infected filament of Ulothrix may accordingly have over a hundred sporangia irregularly distributed along its length. The mature sporangia may be spherical, slightly flattened, and oval, with one to three exit papillae. The spherical ones vary from 9 to 18µ in diameter, with 13.5μ as the average of a hundred sporangia measured at random. Of these sporangia 72 per cent were somewhat anatropus, with the exit papillae sublateral or near the base, 20 per cent had subapical or lateral papillae, and in 8 per cent the papillae were apical. In some thalli the exit papillae may be so near the base that they rest on the surface of the host cell. They may be comparatively low and inconspicuous or protrude $3-4\mu$ beyond the surface of the sporangium. Usually only a single papilla is present, but occasionally two and rarely three may be found. After deliquescence of the papillae the orifices may vary from 3-5µ in diameter.

The wall of the sporangium likewise varies considerably in thickness. In some sporangia it is very thin, while in others it may be $.8-1.7\mu$ in

breadth. Sporangia with such walls do not usually become wrinkled and collapse shortly after the zoospores have emerged. Sometimes an unexpanded portion of the zoospore or semispherical protrusion may be found near the base of the sporangium, as is shown in figures 1g, 1h, and 13, and such sporangia often appear very similar to *Chytridium Schenkii*, *C. gibbosum*, and *C. aggregatum*. These zoospore-case appendages may sometimes become thick walled and darken in color with age.

The most conspicuous feature of the absorbing system of this species is the knob and peg-like structure beneath the sporangium. For the sake of convenience I am calling this structure an haustorium, although as will become evident below, it is apparently not the primary means of food absorption. With the view of emphasizing this structure, I have drawn in figures 2 to 6 some of the variations which it may exhibit in various thalli. As Braun, Serbinow, and Sparrow have already shown, it may be short and tapering, almost filamentous, or inflated at the end to form a small globular apophysis-like structure which may become 4μ in diameter. In length it may vary from 4 to 12μ , and be even (figs. 2, 10, 11) or somewhat irregular in contour (figs. 4, 5, 6). It is usually very narrow in diameter and constricted a short distance below the base of the sporangium (figs. 2, 14), and in very rare instances it may become needle-shaped and run out to a fine point (fig. 15). It may terminate within the layers of the host wall, extend to the latter's inner boundary, or penetrate it completely into the cytoplasm of the cell. Oftentimes the inner boundary of the wall may be pushed in or swollen at the region where the haustorium comes into contact with it, as is shown in my figures 2 and 12, and Braun's figures 23 to 25. An interesting variation is shown in figure 3 in which the haustorium or peg has both an extra- and an intramatrical swelling similar to those of Physorhizophidium pachydermum (Scherffel, 1926; pl. 9, figs. 28, 33, 34). Figure 4 shows an irregular haustorium which extends through the wall and invaginates the plasma membrane. When thalli occur at the junction of two cells, the haustorium may extend down into the cross wall for a considerable distance before bending over and entering the lumen of the cell (figs. 1d, 1g, and 5). In figure 6 is shown a rare case in which the peg is comparatively slender, extends into the center of the cell and branches dichotomously.

The most important discovery in this study, however, is the presence of extremely fine, delicate thread-like branched rhizoids at the tip of the haustorium, which have heretofore been overlooked by previous workers. These rhizoids are so fine and delicate that very high magnifications and a special treatment of the host cells are necessary to render them visible. They have the appearance of delicate, hyaline cytoplasmic strands, and

are usually completely obscured by the host protoplasm. In living preparations they are never as sharply defined and distinct as I have drawn them but for the sake of emphasis I have purposely intensified their appearance. They were first detected in empty dead cells which had become infected, and at diameters of 2800 to 3400 I have been able to see them clearly in a number of instances. As a check on these observations, host cells were specially treated before infection to render them more transparent. Filaments of *Ulothrix* were immersed in potassium hydroxide for half an hour,

Explanation of Plate 31

Fig. 1. Five heavily infected cells of *Ulothrix zonata* showing sporangia in various stages of development.

Fig. 2-6. Variations in the haustorium, five rhizoids and their relation to the host cell wall and protoplasm. Fig. 2. Wall slightly pushed in at the tip of the haustorium, rhizoids branched and unusually extensive. Fig. 3. Haustorium with an extra- and intramatrical swelling. Fig. 4. Haustorium extending through the wall and invaginating the plasma membrane. Fig. 5. An elongated haustorium subtended by numerous fine rhizoids. Fig. 6. A branched haustorium which extends to the center of the host cell

Fig. 7. Zoospores of Rhizophidium laterale.

Fig. 8. Germination of a zoospore on the host cell.

Fig. 9. Gemrination of a zoospore in water.

Fig. 10. An early stage in the development of a sporangium. Protoplasm vacuolate with several conspicuous refractive globules.

Fig. 11. A later stage showing the large central vacuole containing an unusually large globule. Exit papilla apical.

Fig. 12. A more mature anatropous sporangium with non-vacuolate granular greyish protoplasm and a large refractive globule.

Fig. 13. A later developmental stage of a sporangium with two exit papillae and the unexpanded portion of the zoospore case. The protoplasm includes numerous small refractive globules more or less regularly spaced.

Fig. 14. An early stage in the emission of the zoospores.

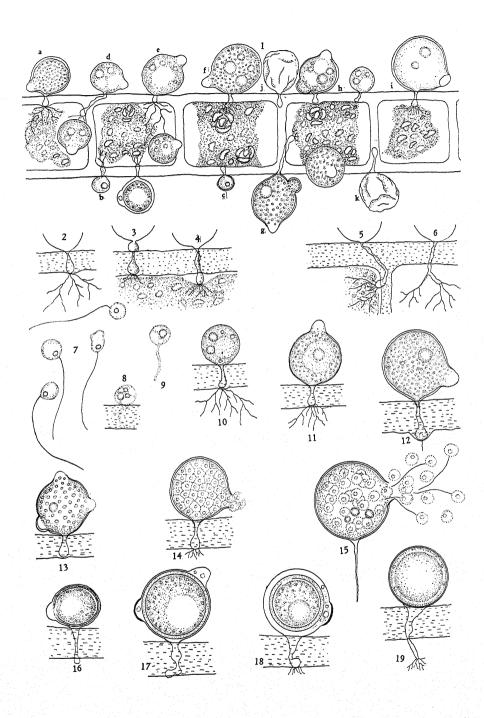
Fig. 15. A later stage after most of the swarmspores have emerged. Two large refractive globules are still present among the zoospores.

Fig. 16. A small oval resting spore with a lateral protrusion in the thin outer wall. Content appears as if it had contracted and encysted with a thicker inner wall.

Fig. 17. A large spherical resting spore with a lateral unexpanded portion of the zoospore case, and the subapical exit papilla of the incipient sporangium from which the spore developed. Inner wall thick yellowish amber and close to the thin outer one, spore content granular with a large vacuole.

Fig. 18. Another resting spore with the thick inner wall considerably removed from the thin outer one, suggesting again that in the incipient stage the contents contracted and encysted. A large refractive globule lies within the spore.

Fig. 19. Another spore in which the differentiation of an inner and outer wall is not distinct. The greater portion of the spore is occupied by a central refractive globule.



KARLING: RHIZOPIYDIUM

rinsed in water, and finally bleached overnight in hydrogen peroxide, which made the cell content optically homogeneous, pale yellowish green, and comparatively transparent. These filaments were then added to normal heavily infected cultures, and after a week a very few infections occurred. With careful examination at the magnifications noted above, the rhizoids of these thalli could be seen rather clearly. They may be branched and extend for a linear distance of 12μ (figs. 1a, 1d, 2, 5, 10, 11) or reduced, short, and brushlike (fig. 3, 4, .4, 18, 19). In several cases only a single short filament has been seen, as is shown in figure 12, while in other instances I have been unable to see them at all.

As has been noted before, these delicate rhizoids at the tip of the haustorium have been overlooked by previous workers, and their presence makes it necessary to transfer this chytrid to the genus *Rhizophidium* if we are to maintain and recognize the present generic distinctions between it and *Phlyctidium*. While I do not believe, in our present state of knowledge concerning the rhizidiaceous chytrids, that these distinctions are of fundamental diagnostic value, I am none the less following Rabenhorst's disposition of this species for the time being.

DEVELOPMENT OF THE SPORANGIA

The zoospores of Rhizophidium laterale are hyaline and almost spherical 2.5-3.2 μ , with a very small clear refractive globule situated toward the posterior end and a $12-15\mu$ long cilium (fig. 7). My observations as to their shape differ thus slightly from those of Braun and Serbinow who describe and figure them as being oval and tapering at the posterior end. I have also observed some of this shape as they are emerging from the sporangia, but after they have been swimming about for some time, they become almost spherical. After coming to rest, the zoospores may undergo slight amoeboid changes in shape and movement, but these never become pronounced. The swarmspores which do not degenerate and come to rest on the host cell soon form a germ tube which penetrates the wall (fig. 8). Germination in water may also occur (fig. 9), but such swarmspores soon degenerate. In the process of germination the refractive globule remains in the spore and soon enlarges in size, and very frequently others appear shortly thereafter (fig. 8). In the meantime the remainder of the cytoplasm usually becomes highly vacuolate. Zoospores may occasionally encyst on the host and develop a comparatively thick wall before or shortly after the germ tube has been formed (fig. 1c), and in subsequent development the incipient sporangium apparently grows out as a vesicle on one side in the same manner as I have described (1938) for Chytridium aggregatum. Although I have not observed their development, I believe this is the manner in which sporangia with zoospore case appendages (figs. 1g, 1h, and 13) arise.

The germ tube increases in diameter and usually enlarges at the tip to become the variously shaped haustorium described above. I have been unable to determine at what stage the delicate rhizoids appear, but I am of the opinion that they grow out from the germ tube after it has become well established as the haustorium. I have not so far observed any extensive branching of the germ tube to form the rhizoidal system as in Diplophlyctis, Endochytrium, Entophlyctis, etc.

In the early developmental stages the incipient sporangia usually possess a large central vacuole and one to several conspicuous refractive globules (fig. 10). The vacuole may persist for a long time, and in some instances include the refringent globules (fig. 11). It gradually disappears as the sporangium matures and the exit papilla are formed. By this time the protoplasm begins to lose its refractive appearance and becomes more greyish granular (fig. 12). After several hours, however, minuted refringent globules again appear in the cytoplasm (fig. 13), and the greyish granular appearance becomes less intense. The small refractive bodies are later included individually in the zoospore initials, It is to be particularly noted in figures 1f, 1g, 12, and 13 that one or more large globules are still present in the cytoplasm, and according to my observations, they do not break up to become included in those minuter bodies which go into the zoospores. In several sporangia in which they were found they persisted throughout the maturation stages, cleavage, and the emergence of the zoospores. While the swarmspores are swarming in the sporangium (fig. 15), they are continually spun and tossed about as extraneous bodies. They may occasionally be found in empty zoosporangia long after all zoospores have emerged (fig. 1i). The occasional presence and persistence of such bodies in the sporangia is unusual for species of Rhizophidium and constitutes the only outstanding aberration I have noted in the development of R. laterale.

In living material the zoospore initials become visible a few hours after the small refractive globules (fig. 13) appear. Swarmspore emergence has been observed but a few times, and I am thus unable to describe the range of variations in the process. The tip of the exit tube gradually deliquesces and a few of the zoospores begin to ooze out through the orifice to form a small globular mass (fig. 14). After a short pause they slowly pull apart and dash away. They do not appear to be imbedded in a large conspicuous globule of hyaline matrix, as in R. sphaerocarpum. After the initial spores have emerged, the remaining ones escape singly, in two's or three's, and, when approximately half of them have passed out, those within the sporangium begin to swarm very actively (fig. 15).

The empty thin-walled sporangia usually collapse partly and become wrinkled after the zoospores have emerged (fig. 1j, 1k), but the thick-walled ones retain their shape for a long time (fig. 1i). Numerous tests with chloro-iodide of zinc have been made on thalli and resting spores in various stages of development, but so far no cellulose reaction has been observed. With such treatment the walls turn yellowish and amber brown.

RESTING SPORES

The resting spores of R. laterale were found in abundance as the evanescent zoosporangia began to disappear in the latter part of June. They are smooth, oval, slightly oblong and spherical, $8-15\mu$ in diameter, hyaline, and yellowish to amber in color at maturity. Serbinow describes them as being hyaline, but I have often found that they may become distinctly amber in color as they grow old. Up to a certain stage they develop in the same manner as the evanescent sporangia, and no sexuality has so far been observed in relation to their formation. In a great number which I have studied the contents of the developing spore appear to have contracted in varying degrees, encysted, and become enveloped by a thick wall (figs. 16, 17, 18). In such cases it is possible to differentiate a comparatively thin hyaline outer wall which looks like an envelope around the spore (fig. 18). The yellowish and amber tint described above seems to be confined to the inner wall. In other instances the inner wall lies very close to the outer one (fig. 17), while in some spores (fig. 19) it is impossible to differentiate between the two. In many of the spores the outer wall has a disc-shaped or semi-spherical protrusion (figs. 16-18) which may often be recognized as a portion of the zoospore case. Occasionally refractive bodies and other small granules may be found between the inner and outer walls (figs. 17, 18).

Unlike most of the other species of *Rhizophidium*, the resting spores of this chytrid usually lack a large central refringent globule. According to my observations the content of the majority of spores is evenly granular with a fairly large central or excentric vacuole (figs. 16, 17). Sometimes, however, spores with globules (figs. 18, 19) may be found, but these appear to be comparatively rare. Figure 17 shows an interesting resting spore with the remains of an exit papilla on the outer wall. In its incipient stages this spore apparently reached the exit-papilla stage of sporangial development, and then its content was transformed into a resting spore. So far fermination of the resting spore has not been observed.

DISCUSSION

As has been noted before, Schenk, Sorokin, and Sparrow reported this

species to occur on *Mongeotia* sp., *Stigeoclonium* sp., and *Spirogyra* sp., in Germany, Russia, and America, but in my cross inoculation experiments involving these hosts I have found no evidence to support their claim. Since these workers found only a few sporangia with lateral exit papillae, no resting spores, and made no cross inoculations with *Ulothrix zonata*, it is difficult to determine whether or not they were dealing with the same species. It is not improbable that several similar species with lateral exit papallae may exist, and until intensive developmental studies of the individual species as well as extensive cross inoculations have been made, we cannot be sure of their exact identity.

Sparrow is further of the opinion that the chytrid which Coker (1923) describes as *R. carpophilum* on oogonia of *Achlya apiculata* is identical with *R. laterale* but, except for the fact that Coker failed to figure a branched rhizoidal system, Sparrow has no basis for his claim.

Fischer, Serbinow, and Minden (1911) regard *Phlyctidium Haynaldii*, described by Schaarschmidt (1883) on *U. zonata* in Hungary, as identical with *Rhizophydium laterale*, but this viewpoint is obviously open to question. Most of the sporangia figured by Schaarschmidt are strikingly different in shape and appearance with one or two conspicuous diverging apical papillae which make them broad at the apex and somewhat triangular in outline. Furthermore, the haustorial knob or peg is absent in most cases, and the absorbing systems consist primarily of an elongated, tapering filament.

In marine plant and animal remnants of Andree's polar expedition Lagerheim (1899) found empty sporangia of a chytrid on *Hormiscia implexa* from Greenland which he believes may relate to *P. Haynaldii*. The empty sporangia, however, are rounder than those described by Schaarschmidt, but since Lagerheim does not further describe or figure them, it is impossible at present to determine their identity.

COLUMBIA UNIVERSITY
DEPARTMENT OF BOTANY

Literature cited

Braun, A. 1855. Über *Chytridium*, eine Gattung einzelleger Schmarotzergerwasche auf Algen und Infusorien. Abh. Kgl. Akad. Wiss. Berlin 1855: 21-83, pls. 1-5.

Coker, W. H. 1923. The Saprolegniaceae. Chapel Hill, N. C.

Fischer, A. 1892. Die Pilze Deutschlands. Oesterreichs und der Schweiz. Rabenh. Kryptog.—Fl. 14.

Karling, J. S. 1938. Two new operculate chytrids. Mycologia 30: 302-312.

Lagerheim, G. 1899. Om växt och djurlämningar i Andrées polarboj. Ymer: 19: 425-443.

- Minden, M. 1911. Chytridiineae, Ancylistineae, Monoblepharidineae, Saprolegniineae. Kryptog. Fl. Mark Brandenburg 5.
- Rabenhorst, L. 1868. Fl. Europ. Alg. 3: 281.
- Serbinow, J. L. 1907. Beiträge zur Kenntniss der Phycomyceten. Scripta Bot. Horti. Univ. Imp. Petropol. 24: 149-173. pls. 1-6.
- Schaarschmidt, J. 1883a. *Phlyctidium Haynaldii* n. sp. Magyar Novenyt. 7: 58-62, pl. 2.
- . 1883b. Phlyctidium Haynaldii n. sp. Hedwigia 22: 125-126.
- Schenk, A. 1858a. Algologische Mittheilungen. Verh. Phys. Med. Gesell. Wurzburg 8: 235-259, pl. 5.
- ——. 1858b. Über das Vorkommen Contraktiler Zellen im Pflanzenreiche. Wurzburg.
- Scherffel, A. 1926. Einiges über neue oder ungenugend bekannte Chytridineen. Arch. Protistenk. 54: 167-260, pls. 9-11.
- Sorokin, N. 1883. Apercu systematique des Chytridiacees recoltees en Russie et claus l'Asia Centrale. Arch. Bot. d. Nord France 2: 1-44.
- _____. 1889. Syphomycetes. Rev. Mycol. 11: 74-75, 81-85.
- Sparrow, F. K. 1932. Observations on the aquatic fungi of Cold Spring Harbor. Mycologia 24: 268-303.

Studies in the Uredinales, the genus Chaconia¹

E. B. MAINS (WITH SIX FIGURES)

The genus *Chaconia* was described by Juel (5) in 1897, the type species being *C. alutacea* based on a collection made by C. A. M. Lindman, July 15, 1893, near Asuncion, Gran Chaco, Paraguay. The host was given as Calliandra, later determined as *Pithecolobium divaricatum* (Borg.) Benth. It was distributed by Vestergren (Microm. rar. sel. 755). Only telia were described. *Chaconia* was known only from the type collection until 1935, when the writer (6) discovered it on a phanerogamic specimen in the Herbarium of the University of Michigan. The specimen was collected by W. A. Shipp (no. 621A) from the Sittee River, British Honduras, Sept. 4, 1930 (figs. 1–2). The host was doubtfully reported as *Pithecolobium Peckii*. It apparently is *P. Recordii*. In addition to telia, pycnia and a few old uredinia were found on this collection.

Juel considered that the species was unusual and not closely related to any rust known at that time. He described and illustrated the teliospores as one-celled, with hyaline, thin walls. He states that they occur in groups of 4 or occasionally 5 or 6 on basal cells and that they are produced in succession, the younger pushing the older to one side as they develop. The teliospores of the collection from British Honduras agree very well with those of the type collection and Juel's description. The pycnia of this collection are subcuticular and the urediniospores are echinulate.

Another collection of this species was discovered in the course of a study of species of Maravalia.² This is a collection on *Pithecolobium glomeratum* collected by E. Ule (no. 3500) at Seringal, Auristella, Rio Acre, Peru, July 1911. The Sydows (7) based their species *Uromyces pallescens* on this collection and later it was transferred to Maravalia (Dietel, 3). This collection has sessile, hyaline teliospores in groups of 2-4 on basal cells (fig. 3). It is evident that this also is *Chaconia alutacea*.

The Sydows (8) have described a species of Blastospora, B. Butleri based on a collection of Jasminum malabaricum collected by S. L. Ajrekar

¹ Papers from the Department of Botany and Herbarium of the University of Michigan. This study developed out of an investigation of tropical American Uredinales supported from the funds of the Horace H. Rackham School of Graduate Studies.

² The writer is indebted to Dr. G. B. Cummins for the loan of collections from the Arthur Herbarium of Purdue University and to Professor G. Samuelsson for collections from the Naturhistoriska Riksmuseet, Sweden.

at Matheran, Bombay, Nov. 15, 1911 (E. J. Butler no. 1603). The teliospores are described as one-celled, clavate-cylindric or fusoid, hyaline, short pedicellate and fasciculate at the base. A study of Sydow Fungi exot. 329 shows that the teliospores develop in groups of 5–9 from the upper portion of a basal cell and are sessile (fig. 4). Blastospora was described by Dietel (2) and based on B. smilacis which has globoid teliospores with well developed pedicels. Blastospora Butleri should therefore be transferred to Chaconia.

Arthur (1) has doubtfully described a species in *Chaconia* under the name *Chaconia* (?) texensis. This was based on a collection on *Phoradendron macrophyllum* (Engelm.) Cockerell, obtained by W. H. Long (947) at Austin, Texas, May 8, 1901. This specimen has been available for study. The fungus develops a pulvinate, pseudoparenchymatous mass, apparently beneath the cuticle. Imbedded in this are one- and two-celled hyaline spores. The manner in which these spores develop is uncertain but it is evident that they are not grouped on basal cells and this is not a species of *Chaconia*. It is not certain whether this is a rust.

Chaconia has been variously placed in the classifications of the Uredinales. The Sydows (9) have placed it in the Melampsoraceae because they considered that the basal cells were more or less united in a layer. They

were uncertain concerning its position in the family.

The basal cells are generative cells. As Juel has pointed out the teliospores bud out from them in succession. The oldest often germinates before the youngest reaches full development (fig. 3). The teliospores are therefore sessile. This sessile character has been considered one of the principal diagnostic characters of the Melampsoraceae. However, the teliospores are not united laterally and do not form compact crusts as in the Melampsoraceae. Apparently *Chaconia* represents a transition from the Melampsoraceae to the Pucciniaceae.

The successive development of a number of teliospores from a basal cell is not unusual in the rusts. In most species however, the basal cells form a compact layer and the lateral budding is not easily demonstrated. In *Chaconia*, the basal cells are laterally free and tear away from the rest of the mycelium in making mounts for the microscope, carrying their teliospores with them.

Several species of *Maravalia*, a genus in the Pucciniaceae with well developed pedicels, have their teliospores grouped on free basal cells. Therefore, *Chaconia* is apparently more closely related to genera in the Pucciniaceae than to any genus which has been included in the Melampsoraceae.

Arthur (1) has included Chaconia in the Aecidiaceae (Pucciniaceae)

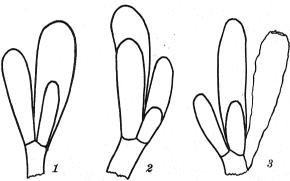
in the subfamily Skierkatae with *Skierka*, *Ctenoderma* and *Sphenospora*. It does not show any close relationship to these genera which have a very different development of their teliospores.

Dietel (4) has placed *Chaconia* in the Pucciniaceae in the tribe Oliveae with *Calidion*, *Olivea*, *Chrysocelis*, and *Goplana*. This appears to be a logical position for it. The teliospores of *Olivea* develop in a very similar manner.

CHACONIA Juel, Bihang K. Svenska Vet.—Akad. Handl. 23: 12. 1897.

Pycnia subcuticular. Uredinia subepidermal, pulverulent; urediniospores obovoid to ellipsoid, echinulate or finely verrucose in irregular lines. Telia subepidermal, soon naked; teliospores clavate to cylindric, hyaline, thin-walled, sessile arising in succession from basal cells, a number from a basal cell, the basal cells free laterally, germinating immediately.

Type species Chaconia alutacea Juel.



Figs. 1-3. Chaconia alutacea. 1 and 2, groups of teliospores from Shipp's collection no. 621A; 3, group of teliospores from the type of *Uromyces albescens*; the spores are in various stages of development, one having germinated in fig. 3. \times 600.

CHACONIA ALUTACEA Juel, Bihang K. Svenska Vet.—Akad. Handl. 23: 12. 1897.

Uromyces albescens Syd. Ann. Mycol. 14: 66. 1916.

Maravalia albescens Syd. in Dietel. Ann. Mycol. 22: 270. 1924.

Pycnia amphigenous, subcuticular, lenticular, $20-24\times60-70\mu$.

Uredinia hypophyllous, subepidermal, grouped in somewhat hypertrophied tissue opposite the pycnia, 0.5–1 mm. in diameter; urediniospores ellipsoid, $16-20\times22-26\mu$, the wall cinnamon-brown, 2μ thick, moderately echinulate, the pores obscure.

Telia hypophyllous, subepidermal, small, scattered or in small groups; teliospores clavate or cylindric, $10-18\times40-70\mu$, the wall hyaline, very thin, 0.5μ , sessile, 2-4 sometimes 5-8 arising in succession from a basal cell, germinating at once (figs. 1-3).

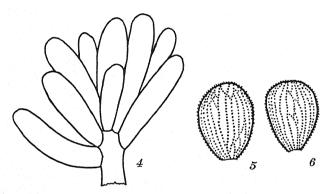
Specimens examined:

Pithecolobium divaricatum (Borg.) Benth. Asuncion, Gran Chaco, Paraguay, July 15, 1893, C. A. M. Lindman (Vestergren, Microm. rar. sel. 755) type.

Pithecolobium glomeratum Benth. Serigal, Auristella, Rio Acre, Peru, July 1911, E. Ule (3500).

Pithecolobium Recordii Standl. Sittee River, British Honduras, Sept. 4, 1930, W. A. Shipp (621A).

Juel (5, pl. 3, fig. 15) shows a basal cell which is branched with four spores on each branch. In the specimens examined only simple basal cells have been noted with a maximum of 6 spores.



Figs. 4-6. Chaconia Butleri. 4, group of teliospores; 5 and 6, urediniospores, surface view to show markings. \times 600.

CHACONIA BUTLERI (Syd.) nov. comb.

Blastospora Butleri Syd. Ann. Mycol. 10: 266. 1912.

Uredinia hypophyllous, subepidermal, on discolored spots up to 1 cm. across, more or less circinating, pale yellow, pulverulent; urediniospores obovoid or ellipsoid, $18-24\times26-34\mu$, the wall hyaline, $2-3\mu$ thick, finely verrucose in irregular longitudinal lines which somewhat anastomose, the pores obscure (figs. 5-6).

Telia hypophyllous, subepidermal, associated with the uredinia, pale brown, pulvinate, waxy; teliospores cylindric or clavate, $9-12\times44-54\mu$, the wall hyaline, very thin, 0.5μ , sessile, 5-9 arising in succession from a basal cell, germinating immediately (fig. 4).

Specimen examined:

Jasminum malabaricum Wright, Matheran, Bombay, India, Nov. 5, 1912, S. L. Ajrekar (Syd. Fungi exot. exsicc. 329).

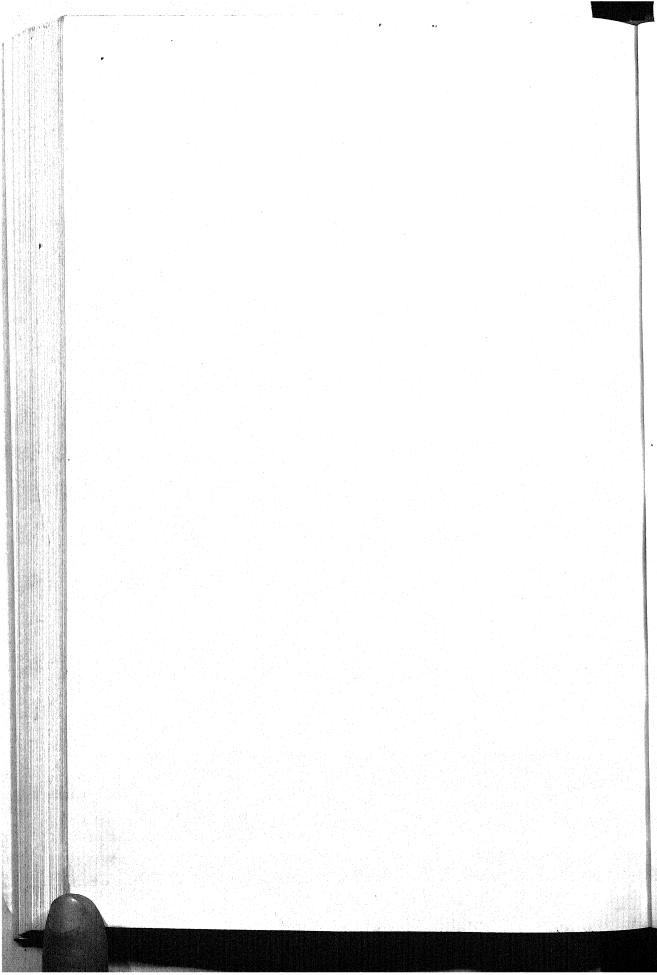
The urediniospores of this collection are pedicellate. The verrucose

markings in lines give a beaded appearance to the spores. The teliospores occur in various stages of development in definite clumps on basal cells.

University Herbarium University of Michigan Ann Arbor, Michigan

Literature cited

- 1. Arthur, J. C. Uredinales. N. Am. Flora 7: 734. 1926.
- 2. Dietel, P. Uredineen aus Japan. II. Ann. Mycol. 6: 222-229. 1908.
- 3. Dietel, P. Kleine Beiträge zur Systematik der Uredineen. IV. Ann. Mycol. 22: 269-273. 1924.
- 4. Dietel, P. Uredinales in Engler and Prantl. Nat. Pflanzenfamilien 6: 54. 1928.
- 5. Juel, H. O. Die Ustilagineen und Uredineen der ersten Regnell'schen Expedition. Bihang. K. Svenska Vet.- Akad. Handl. 23: 3-30. 1897.
- 6. Mains, E. B. Rusts and smuts from the Yucatan Peninsula. Carnegie Inst. Washington Pub. 461: 95-106. 1935.
- 7. Sydow, H. and P. Fungi amazonici a. cl. E. Ule lecti. Ann. Mycol. 14: 65-97. 1916.
- 8. Sydow, H. and P. and Butler, E. J. Fungi Indiae orientalis, pars IV. Ann. Mycol. 10: 243-280. 1912.
- 9. Sydow, P. and H. Monographia Uredinearum. 3: 421-422. 1915.



The cytology of Cuscuta

Sidney O. Fogelberg (WITH PLATE 32)

INTRODUCTION

Investigations of the physiology, morphology and taxonomy of various species and groups of species within this large genus (about 159 species) have been numerous. (For bibliography see Yuncker, 1920, and Dean, 1937.) The most extensive treatment of the genus to date is the monograph by Yuncker (1932), and the present paper follows his nomenclature. Where synonyms have been used by workers cited, Yuncker's accepted name is given in parentheses.

Fedortschuk (1931) observed the haploid number of chromosomes of *C. epithymum* Murr. to be 7. His lateral views of the division of the microspore nucleus seem to be the only published figures of equatorial-plate chromosomes in any species of Cuscuta.

Finn and Safijovska (1934), investigating microgametophyte-development and the numbers and forms of the chromosomes in divisions of somatic as well as of "haploid" nuclei (presumably in the pollen grain) report the following numbers:

C. epithymum Murr. var. vulgaris Engelm. (C. epithymum Murray)	n = 7	2n = 14
C. europaea L.		2n = 14
C. epilinum Weihe	n = 21	2n = 42
C. arvensis Beyr, var. calvaina Engelm. (C. campestris Yuncker)	n = 28	2n = 56

As these authors point out, this is evidently a polyploid series with the basic number 7. Two of the three subgenera into which the genus is divided are represented. They find further evidence as to the basic number in the fact that one large chromosome for each set of 7 is present in both haploid and diploid nuclei in all four species.

According to Yuncker, C. epilinum, C. epithymum, and C. europaea belong to the subgenus Cuscuta. C. campestris is included in the subgenus Grammica. The only representative of the subgenus Monogyna which Finn and Safijovska examined was C. monogyna Vahl. Although the chromosome number was not determined, it differs from the others studied in having much larger chromosomes. It was found to be unique, too, in certain details of development of the microgametophyte, so that there apparently exists here an observable correlation between the cytological details and the previously observed morphological characters upon which taxonomists have based the major divisions of the genus. However, the authors point out that any statement in regard to evidence of inter-

[VOL. 65

relationships from cytological observations must carry little weight until a larger number of species has been investigated.

MATERIALS AND METHODS

Seeds of *Cuscuta* species were obtained from collections of mature capsules and from specimens in the herbaria of the following institutions: Missouri Botanical Garden, the University of Michigan, the University of Wisconsin, and the Gray Herbarium. The species studied and the places of collection of the plants producing seeds are as follows:

- C. Gronovii Willdenow, Madison, Wis.
- C. Cephalanthi Engelmann, Madison, Wis.
- C. glomerata Choisy, Port Byron, Ill.
- C. compacta Jussieu, Langely, Ark.
- C. pentagona Yuncker, Greencastle, Ind.
- C. campestris Yuncker, Quitman, Ark. C. Coryli Engelmann, Wonewoc, Wis.
- C. indecora var. neuropetala, (Engelm.) Hitchcock, Ashley, N.D.

The seeds were germinated in moist chambers after the seed coats had been nicked or scarified. When the seedlings were about 2 cm. long they were placed on stems or petioles of a host plant under a bell jar. When one of the seedlings had formed prehaustoria the bell jar and the remaining seedlings were removed. The host plants were chosen to some extent from the lists given by Yuncker (1932) and Dean (1934, 1935); but for the most part a number of available greenhouse plants were tried and those which appeared most favorable were retained.

Most of the cytological work was done on flower buds, but a few stem tips and stems with incipient haustoria were used for study of the somatic divisions. A variety of fixatives and stains were used with all species, but for all but C. pentagona, C. campestris, and C. compacta fixation in Belling's modification of Navashin's fluid followed by the crystal violet-iodine stain proved most satisfactory, especially for the study of chromosomes at or near the equatorial-plate stage. C. pentagona and C. campestris, although appearing to be satisfactorily fixed in both Belling's and Randolph's modifications of Navashin's fluid when stained in Heidenhain's iron-alum haematoxylin, could not be induced to take a satisfactory crystal-violet stain. C. compacta was most satisfactorily fixed in Flemming's strong solution.

The material was imbedded in paraffin and sectioned at thicknesses of $5-12\mu$ for the study of equatorial-plate chromosomes and of $18-30\mu$ for the study of diakinesis and other prophase stages.

A few preparations were made using the aceto-carmine smear technique

and a few according to Taylor's smear method, but the minuteness of the anthers made both these procedures unsatisfactory.

OBSERVATIONS

Examinations of longitudinal and transverse sections of the developing primary roots of seedlings of C. Gronovii, C. Cephalanthi, C. Coryli, C. glomerata, and C. pentagona revealed no indication of nuclear or cell division from the time a root emerges from the seed until it has reached its full length (about $1-1\frac{1}{4}$ cm). These observations and the comparatively close similarity of the root portion of the long, coiled, dormant embryo to the peculiar root (Hooker, 1898) developed from it make it appear likely that all the cells of the root are present in the embryo when the seed reaches maturity. However, it still remains possible that some divisions may occur between the beginning of activity of the embryo and the time that the root appears through the seed coat.

Somatic mitoses were studied to some extent in stem tips, young buds, and in a few cases in the early stages of haustorium-formation, but because of the difficulty of finding satisfactory division figures in these places the study was confined largely to the divisions of the microspore mother cells.

C. Gronovii Willd. n = 30

The seeds from which plants of this species were grown were collected in the University Arboretum in the fall of 1936. Impatiens Sultani Hook. and Coleus Blumei Benth. var. Renhaltianus proved satisfactory hosts. Growth was slightly less vigorous on common geranium (Pelargonium hortorum Bailey). No cytological difference was observed between material grown on these different hosts, but since all allowed a normal growth of the dodder the possibility of cytological abnormalities in plants drawing their substance from more unfavorable hosts is not excluded. Kindermann (1928) reports amitosis in a large haustorial cell of Cuscuta Gronovii growing poorly on Nicotiana rustica and attributes it to the unfavorable action of materials taken from the host. One case of apparent amitosis was observed in this species in the present study, although the host (Impatiens Sultani) appeared to be in no way unfavorable. The cell in which it occurred was one of the system of large lactiferous cells (Peirce, 1893) which runs through the whole plant, this one being in a petal.

Microspore-mother-cell nuclei at diakinesis (fig. 4) possess 30 mostly well-separated chromosome pairs which can be counted without great difficulty if stained with Flemming's triple stain or with crystal violetiodine. With these stains the nucleolus is differentiated so that it does not hinder the distinguishing of the 4, 5, or 6 pairs that are commonly clustered

about that body. Most of the pairs lie in the peripheral region of the nucleus. In some preparations delicate strands are observed to connect many of the pairs with one another.

Although about six of the pairs have only one chiasma each in most late diakinetic nuclei and some pairs occasionally show more than two chiasmata (the interstitial one and sometimes one of the terminal ones in these cases appearing as delicate strands), the chromosomes of the majority of the gemini at this stage are in contact at both ends and are comparatively widely separated in the intermediate region. This condition, developing from a diplotene and early diakinetic condition in which the average number of points of contact between members of the pairs is certainly greater, may be interpreted as the result of terminalization of chiasmata (Darlington, 1932).

One of the V-shaped pairs (a, fig. 4) is conspicuously heteromorphic. Besides characteristic differences in outline between the two members, one of them is about 1.6μ , the other about 2.3μ long. This pair and about 6 others can be identified with a fair degree of assurance in many diakinetic nuclei. Identifications correlative with these have not yet been made in earlier stages, but the distinctive appearance of some of the diakinetic

pairs suggests that possibility.

In most heterotypic equatorial plates (fig. 1) connecting strands are evident between a number of the chromosome pairs which are far enough apart in the plates to allow a view of such structures. The presence of these suggests that the strands, mentioned earlier as being visible in some diakinetic nuclei, remain as the chromosomes pass to the equatorial plate, becoming shorter along with the chromosomes. The chromosome pairs at the heterotypic equatorial plate vary from nearly spherical (with a diameter of 1μ to 1.8μ) or angular and approximately isodiametric to somewhat elongated with the longest axis of any pair not found to exceed 2.2μ .

The chromosomes in the homoeotypic equatorial plates are more angular, generally more widely separated, without connecting strands, and, of course, smaller than are the pairs of chromosomes at the heterotypic equatorial plate.

A nucleolar bud, about 1.4μ in diameter, with a satellited chromosome pair associated with it at its base (fig. 3), was observed in a microsporocyte nucleus apparently in a pachytene stage. Such buds are typically present in this species, but the associated satellite chromosome cannot from the observations made be said to be a constant feature.

While the nucleolar bud just described is fairly typical as to size and form, variations appear in size, number, and relative position of buds on

the nucleolus. A bud or buds may or may not be present at a particular stage. An unusual size variation is shown in figure 2, where the "bud" is almost as large as the main body of the nucleolus. In a relatively large number of diakinetic nuclei two buds have been observed on a single nucleolus, these most often being 180° apart and usually each having a pair of chromosomes (not visibly satellited) in contact with it. The nucleolus shown in figure 4 bears two buds about 90 degrees apart, each having a chromosome pair directly above and apparently in contact with it.

Some tapetal nuclei undergo mitosis when the microsporocyte nuclei are in synizesis. A slightly greater number of these tapetal divisions is seen just after synizesis. All the tapetal cells normally become binucleate, and the majority of them remain in that condition until the cells and finally the nuclei disintegrate during the growth period of the microspores. The time at which the majority of the tapetal cells become binucleate is slightly later than that reported in *C. reflexa* Roxb. (Johri 1935). Frequently several of the tapetal cells of a locule are 4-nucleate at the time the pollen-mother-cell nuclei are in diakinesis, and in a few rare cases tapetal cells with 6 or 8 small nuclei are seen.

The nuclei of all somatic cells in the metabolic condition show chromocenters. Exact counts of these were not found feasible, but in some cases it appears that the number about equals the number of chromosomes (60). In other cases, however, the number of chromocenters is much less.

C. Cephalanthi Engelm. n = 30

The 30 pairs of chromosomes which constitute the heterotypic equatorial plate (fig. 7) of this species are similar to those of *C. Gronovii* in size as well as in number. A tendency for more of the pairs to appear biscuit-shaped in polar view than in *C. Gronovii* is not so pronounced in the plate shown as in many of the others seen. Whether this slight difference between the two species is due only to the orientation of the equatorial-plate chromosomes, or whether there is an actual difference in the form of the chromosomes, could not be ascertained by a study of lateral views of equatorial plates. The threads connecting several of the pairs in the heterotypic equatorial plate are interpreted as in *C. Gronovii* to be structures which existed in earlier stages and which have persisted. These threads are not seen in the homoeotypic equatorial plate (fig. 6).

The most conspicuous cytological difference between this species and *C. Gronovii* is found in the appearance of the chromosomes at diakinesis. Whereas in the late heterotypic prophases of *C. Gronovii* there is a relatively long period during which 30 distinct and well-separated pairs of chromosomes are found, *C. Cephalanthi* shows from about 15 to 21 as-

sociations of chromosomes some of them evidently groups of four (fig. 9). One such group from a nucleus at a slightly earlier stage (fig. 10) is shown which appears to consist of two chromosomes in a ring and (probably) two others attached. To insure against the possibility that nuclei or portions of nuclei of an earlier stage (diplonema and early diakinesis) were being

Explanation of plate 32

All drawings were made at a magnification of \times ca. 2000 with the aid of a camera lucida.

Fig. 1. Heterotypic equatorial plate of C. Gronovii; n = 30.

Fig. 2. Nucleolus with large bud and associated chromosomes, from a post-synizetic pachytene nucleus of C. Gronovii.

Fig. 3. Satellite chromosome pair associated with a nucleolus and bud in a nucleus similar to that from which figure 2 was drawn.

Fig. 4. Nucleus of *C. Gronovii* pollen mother cell with 30 pairs of chromosomes at diakinesis.

Fig. 5. Pair of apparently satellite chromosomes from a pollen mother cell nucleus of *C. Gronovii* at diakinesis.

Fig. 6. Homoeotypic equatorial plate of C. Cephalanthi; n = 30.

Fig. 7. Heterotypic equatorial plate of C. Cephalanthi.

Fig. 8. Optical section of a pollen mother cell of *C. Cephalanthi* in a late homoeotypic prophase showing one of the groups of chromosomes scattered on a multipolar spindle. Circles represent extra-nuclear nucleoli.

Fig. 9. Three apparently tetravalent chromosome groups from a mid-diakinetic

nucleus of C. Cephalanthi.

Fig. 10. Apparently tetravalent chromosome group in C. Cephalanthi at a slightly earlier stage than that of figure 9.

Fig. 11. Heterotypic equatorial plate of C. glomerata; n = 15.

Fig. 12. Heterotypic equatorial plate of C. compacta; n = ca. 15.

Fig. 13. Homoeotypic equatorial plate of C. pentagona; n = ca. 28.

Fig. 14. Homoeotypic equatorial plate of C. campestris; n = 28.

Fig. 15. Heterotypic equatorial plate of C. Coryli; n = 15.

Fig. 16. Equatorial-plate chromosome from a cell of a petal of C. Coryli.

Fig. 17. Equatorial-plate chromosome 16μ long from a cell of a petal of *C. indecora* var. neuropetala.

Fig. 18. Satellite chromosome from same plate as figure 17.

Fig. 19. Satellite chromosome near nucleolus; prophase in a tapetal nucleus of C. *Cephalanthi.

Fig. 20. Heterotypic prophase nucleus of *C. campestris* with dark-staining portion in nucleolus in contact with a chromosome.

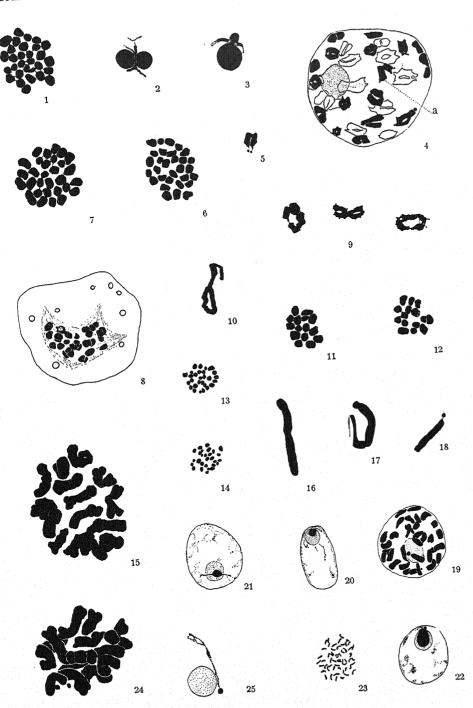
Fig. 21. Similar to figure 20. Different view.

Fig. 22. Similar to figures 20 and 21; an earlier stage.

Fig. 23. Equatorial plate from a cell of an ovule primordium in C. campestris; 2n = 56.

Fig. 24. Heterotypic equatorial plate of C. indexora neuropetala; n = 15.

Fig. 25. Large satellite on chromosome in contact with nucleolus in an early heterotypic prophase in *C. indecora neuropetala*.



FOGELBERG: CUSCUTA

compared with the stage of C. Gronovii shown in figure 4 (middle or late diakinesis), a large amount of material was cut at a sufficient thickness $(28\mu \text{ and } 30\mu)$ to give a high incidence of whole nuclei at all possible stages. In one nucleus in which the nucleolus had disappeared and the nuclear membrane was not evident, about 24 separate groups of chromosomes were counted. Some of these had taken on the smooth outline and contracted appearance of chromosome pairs moving toward the equatorial plate. The rather disorganized orientation and distribution of the chromosome pairs or groups in this nucleus made impossible the interpretation of a large proportion of them or even the reliable counting of the number of actually separate associations.

The tapetal cells become binucleate in this species, as in *C. Gronovii*, to some extent while the microsporocyte nuclei are in synizesis but mostly just after synizesis. In this species, too, a small number of the tapetal cells become 4-nucleate. The second tapetal nuclear division occurs usually while the microsporocyte nuclei are at about the diplotene stage. Preparations suggesting fusions of tapetal nuclei at the time the microspores are

in tetrads are not uncommon.

In a few locules in which the microsporocyte nuclei had undergone the heterotypic division the chromosomes were scattered on multipolar spindles (fig. 8, showing one of the two spindles in the cell). Two interpretations are possible from the appearance of these preparations. Either these spindles are the result of abnormal conditions in the genetic constitution or environment of the plant and would probably result in the formation of more than 4 microspore nuclei in each cell; or they are a normal stage preceding the formation of the bipolar spindles, as is the case in the heterotypic division in various other plants. The second interpretation is favored here because no evidence of abnormality was seen in other locules of the anthers or in other anthers of the flowers in which these multipolar homoeotypic spindles occurred. The microspores and pollen grains, too, appear from their size and staining reactions to be entirely normal in this species.

Extra-nuclear nucleoli of various sizes are abundant in the microsporocytes of this species (fig. 8) as well as in C. Gronovii. These bodies become apparent in the cytoplasm when the nucleolus and nuclear membrane have disappeared in preparation for the heterotypic division. They are spherical or nearly so in shape, generally less than 1μ in diameter, and stain in the same manner as ordinary nucleoli with Flemming's triple, crystal violet-

iodine, and Heidenhain's iron-alum haematoxylin stains.

C. glomerata Choisy n=15

The seeds from which this species was grown were collected near Madison. Aster sp. was used as a host.

The average size of chromosomes in this species (fig. 11) is slightly larger than in the two preceding. The nuclei at diakinesis possess pairs of chromosomes most of which have 2 terminal chiasmata and rather widely separated intermediate portions. The chromosomes were counted in the heterotypic and homoeotypic equatorial plates and in the homoeotypic prophases. The latter stages are very satisfactory for counting, for although the chromatids often diverge widely the chromosomes are generally separated and distinct.

Fixation of buds of this species, in order to be successful, must be preceded by removal of the many papery bracts.

C. compacta Juss. n = ca. 15

The fifteen pairs of chromosomes in this species (fig. 12) are similar to those of C. glomerata. The average size of the chromosome pairs in the heterotypic equatorial plate is about 1.5μ by 1.75μ . Cytological study is made difficult by large quantities of a substance (perhaps tannin) which darkens when the cells are fixed. The chromosomes have been counted only in heterotypic equatorial plates and in some homoeotypic plates which were all questionable in certain portions. Hence the number is not positively determined, but it appears to be that given.

C. pentagona Engelm. n = ca. 28

Seeds of this species were collected by Prof. Yuncker near Greencastle, Indiana, in 1936. One of the three instances of hosts proving definitely unfavorable was found when this species was tried on *Tropaeolum majus*. After growing slowly on this host for about 8 weeks, a few flowers were produced. When growing tips of the dodder were placed on plants of *Pelargonium hortorum* a 5-week period of vegetative growth followed after which an abundance of flowers appeared.

The minuteness of chromosomes of this species and of the very similar C. campestris offers difficulty in the counting. The average size of the chromosomes in the homoeotypic equatorial plate (fig. 13) is about 0.5μ by 0.7μ , and in the heterotypic equatorial plate 0.7μ by 0.8μ . The somatic chromosomes vary in length from about 0.4μ to 1.2μ .

C. campestris Yuncker n=28, 2n=56

The seeds from which material of this species was grown were taken from a specimen in the herbarium of the Missouri Botanical Garden col-

lected at Langley, Arkansas, in 1933. Professor Yuncker verified the identification.

The species was studied by Finn and Safijovska (1934) and their counts are here confirmed. Figure 14 shows 28 chromosomes in a homoeotypic equatorial plate, and figure 23 about 56 chromosomes in a somatic plate.

No marked cytological difference between this species and *C. pentagona* was observed. A portion of the interior of the nucleolus stains more deeply than the rest in iron alum-haematoxylin material destained until prophase chromosomes are only faintly visible (figs. 20, 21, 22). This darkly stained portion of the nucleolus is connected with a chromosome pair throughout the prophases of the heterotypic division. This darker-staining portion varies considerably in size in different pollen sacs, but the nucleoli in a given sac present little variation. In all cases the darker portion is eccentrically located. The constant location, the connection with a chromosome pair, and the sharply defined outline of this portion of the nucleolus, as well as the fact that in different locules of the same preparation the darker portion varies considerably in size, indicate that the variation is not due to different degrees of destaining.

C. Coryli Engelm. n = 15

This species was grown on *Tropaeolum majus* and to some extent on the garden pea. On Coleus it behaved in the manner described for *C. pentagona* on *Tropaeolum*.

This species has much larger chromosomes than any of those previously mentioned. Those of the longest pair in the heterotypic equatorial plate (fig. 15) are about 8μ in length, the shortest about 4μ . The diameter varies considerably, from about 1μ to more than $2\frac{1}{2}\mu$, and the outlines of the chromosome pairs are rough and irregular. A constriction or a clear space marking the fiber-attachment region is visible in some of the chromosomes. Lateral views often show the chromosomal material at the fiber-attachment region drawn out to a point on either side.

Since several of the chromosome pairs are very similar, I have not attempted to identify all. However, certain pairs can usually be recognized in different heterotypic equatorial plates. Two V-shaped pairs about 7μ long and conspicuously double at both ends are commonly seen, and one (occasionally both) of these shows a median clear region. The longest pair has a thicker portion between the median, constricted region and one end. A short pair $(4\mu \text{ long})$ usually appears double at one end, tapering to a blunt point at the other. This peculiar chromosome appears also in the species next to be mentioned.

Nucleolar buds of varying size were seen in heterotypic prophases. In some diplotene nuclei a chromosome is in contact with the nucleolus at the base of a bud. In others no chromosome is seen near the bud. The relative length and a marked clear region near the opposite end of each chromosome of the attached pair may identify it with one of the pairs seen in somatic cells which agree in these characteristics and which possess a satellite on the end farther away from the clear region. A study of somatic prophases might establish this identity more definitely. A tapetal cell with more than two nuclei has never been observed in this species or in *C. indecora* and many of them remain uninucleate throughout their existence.

The seeds from which this species was raised were taken from a specimen collected at Wonewoc, Wisconsin, in 1917. Since old seeds have been shown in some cases to give rise to plants showing a greater number of genetic and chromosomal mutations and mitotic irregularities (Crocker, 1938) than do younger seeds, evidence of irregularity was looked for in this plant. In an appreciable number of cases sister chromosomes were observed to be not completely separated at full anaphase, *i.e.*, when the daughter groups were as far apart as they would ever be. Similar conditions were occasionally observed in heterotypic and homoeotypic anaphases as well as in somatic divisions. However, the mechanical difficulties in the separation of such extremely long chromosomes as are present in this and the next species may account for the few instances indicating irregularity which have been observed. The pollen appears to be almost completely normal.

C. indecora var. neuropetala (Engelm.) Hitchcock n=15

The seeds of this variety were taken from a Gray Herbarium specimen collected at Ashley, North Dakota, in 1934. *Pelargonium* was used as a host, since it allowed a more luxuriant growth than the other hosts tried (*Coleus, Convolvulus*). The *Pelargonium* formed a conspicuous gall in response to the penetration of the first few haustoria, smaller ones later.

This variety has not been as extensively studied as has C. Coryli, but the counts of heterotypic (fig. 24) and homoeotypic equatorial plates indicate that 15 is the haploid number and that the chromosomes are similar to those of C. Coryli. Besides the peculiar short chromosome pair mentioned for C. Coryli, which is very similar to one in the present species, several others may possibly be identified in the two species by further study. The chromosomes of the satellite pair (fig. 18) in C. indecora var. neuropetala, though, are considerably shorter than the members of the satellite pair in C. Coryli and lack the broad clear region seen in the latter

case. Measurement of one of the larger somatic chromosomes (fig. 17) seen in the equatorial plate shows it to be about 16 or 17μ in length, the largest observed in the genus.

DISCUSSION

The eight species studied fall into four rather widely separated groups representing five of the twelve sub-sections of the section Cleistogrammica, sub-genus Grammica. In general, the cytological evidence in regard to phylogenetic relationships within and among the sub-sections investigated agrees with the scheme based on morphological characters which Yuncker (1932) has suggested. Certain exceptions, however, may be pointed out.

According to Yuncker the sub-section Cephalanthae, containing only C. Cephalanthi, is probably derived from the sub-section Oxycarpae. To the latter sub-section, which includes C. Gronovii and its two recognized varieties, belong also C. curta (Engelm.) Rydberg and C. rostrata Shuttleworth. These two species do not approach C. Cephalanthi as closely in morphological characters as does C. Gronovii. Hence, if the ancestor of C. Cephalanthi is to be looked for among extant representatives of this sub-section, C. Gronovii and its varieties appear from morphological evidence to be the only likely possibilities. The chance that the varieties of C. Gronovii differ cytologically from the typical form appears slight from what is known concerning closely related species in the genus as well as of similar cases in other genera. The behavior of the chromosomes in diakinetic nuclei of C. Cephalanthi and C. Gronovii is hardly consistent with the idea that the latter species is the ancestor of the former, since it is unlikely that so many tetravalent associations would have developed among chromosomes which had once formed only bivalents at this stage. Another possibility is that the two species have resulted from a parallel development. If both originated from types with 15 pairs of chromosomes, then it would seem likely either that C. Gronovii is an allotetraploid or that the original pairs of homologous chromosomes have developed enough genetical differences since the origin of this plant so that now little evidence of multivalent association is seen. On the other hand, the occurrence of tetravalent chromosome associations in C. Cephalanthi suggests that it may well be an autotetraploid. In any case, the similarity between the two species in cytological details, in external morphology, and in geographical distribution indicates that their ancestries converge at a relatively nearby point in the phylogenetic system.

The sub-section Lepidanche, which includes C. glomerata and C. compacta, is suggested by Yuncker as being derived from the subsection Oxycarpae (including C. Gronovii). Cytological evidence of such relation-

ship has not been found. However, if some representative of the Oxycarpae should be found to have 15 pairs of chromosomes, a possible line of development would be evident. C. rostrata appears somewhat more closely related to the sub-section Lepidanche than others of the Oxycarpae. The chromosomes of C. Gronovii and C. Cephalanthi do not differ markedly from those of C. glomerata or of C. compacta in size or form, suggesting a possible fairly close relationship.

None of the forms studied is in the suggested line of ancestry of the sub-section Indecorae, in which C. Coryli and C. indecora var. neuropetala are placed. A comparison of the average chromosome size in these two as compared with other species in the genus (especially C. campestris and C. pentagona) shows a range of divergence which is unusual within a genus. As Yuncker's (1932) diagram indicates, these two related species probably fall in a different line of development from any of the others investigated. Finn and Safijovska (1934) pointed out the great difference in chromosome size between C. monogyna and other species studied by them and cite the work of Heitz (1926). Heitz found great variation in average chromosome size between species of Cyclamen, those with larger chromosomes having in every case a more northerly distribution. Although the two largechromosomed species of Cuscuta (C. Coryli and C. indecora neuropetala) do occur farther north (both occurring in North Dakota and C. Coryli in central Wisconsin) than a majority of the species in the genus, it appears more significant in this case that it is the two species with 60 mediumsized chromosomes which range farther north than do any of the others. Several cases have been pointed out (Hurst, 1927; Anderson, 1937) in which the members of a polyploid series possessing the higher chromosome numbers have the more northerly ranges.

Another apparently distinct line of evolution among the American species of dodder is that which has given rise to *C. pentagona* and *C. campestris*. The form and extremely small size of the chromosomes and the existence of a different basic number in these two species sets the subsection Arvenses apart from all others studied. The fact that these species have 28 pairs of chromosomes rather than some multiple of 15 as do the others studied is probably correlated with the occurrence of polyploid series with the basic number 7 in certain representatives of the sub-genera Cuscuta and Monogyna.

In the section Eucuscuta of the sub-genus Cuscuta, Finn and Safijovska find two species with a haploid chromosome number of 7 and one with a haploid number of 21. If this section does represent the present climax of one line of development within the genus, as Yuncker's suggested scheme indicates, then it seems improbable that some of the representa-

tives of the intermediate and most primitive groups too do not possess a haploid number of 7. However, the possibility remains that such forms,

formerly existent, may have disappeared.

In the sub-genus Monogyna, which is suggested to have developed as an offshoot from forms of the sub-genus Cuscuta which preceded the section Eucuscuta in phylogeny, only *C. monogyna* has been investigated cytologically. Finn and Safijovska (1934) report this species to have 14 pairs of rather large chromosomes. If the true line of development of the sub-genus is that suggested, there is an indication that forms with a small number of chromosomes and with a basic number of 7 do exist or have existed in the more primitive groups of this sub-genus.

SUMMARY

The evidence indicates that all the cells of the mature root of a dodder seedling are present in the dormant embryo.

The following chromosome numbers are reported:

C. Gronovii Willd. n = 30;

C. Cephalanthi Engelm. n = 30;

C. glomerata Choisy n = 15;

C. compacta Juss. n. = ca. 15;

C. Coryli Engelm. n = 15;

C. indecora neuropetala (Engelm.) Hitchcock n=15;

C. pentagona Engelm. n = ca. 28;

C. campestris Yuncker n = 28, 2n = 56.

C. Gronovii and C. Cephalanthi have chromosomes similar in size but differing in their behavior in meiosis; those of C. Gronovii forming 30 separate pairs and many of those of C. Cephalanthi appearing in groups of four. A satellite chromosome pair is present in association with the nucleolus, often attached at the base of a nucleolar bud, in C. Gronovii. The tapetal cells in both species become binucleate during or just after synizesis.

C. glomerata and C. compacta have chromosomes similar to those of

C. Cephalanthi and C. Gronovii.

The chromosome pairs in the heterotypic equatorial plate in C. Coryli and in C. indecora neuropetala are relatively very large, varying from 4μ to 8μ in length. Distinctive sizes, constrictions, and achromatic regions allow the identification of several of the pairs from one equatorial plate to another in C. Coryli and probably in C. indecora neuropetala as well. Certain chromosomes of either correspond in size and morphology with chromosomes of the other species.

C. campestris and C. pentagona have extremely small chromosomes;

the difference in average chromosome size as between these and the two very large-chromosomed species previously mentioned is unusual in a single genus of plants.

Certain suggestions regarding relationship of species within the genus

are furnished by the cytological facts available.

The writer wishes to express his gratitude to Professor C. E. Allen for criticisms and suggestions.

DEPT. BOTANY UNIVERSITY OF WISCONSIN MADISON, WISCONSIN

Literature cited

Anderson, E. 1937. Cytology in its relation to taxonomy. Bot. Rev. 3: 335-350.

Crocker, W. 1938. Life-span of seeds. Bot. Rev. 4: 235-274.

Darlington, C. D. 1932. Recent advances in cytology. London.

Dean, H. L. 1934. Host plants of Cuscuta Gronovii. Rhodora 47: 371-374.

——. 1935. Host plants of Cuscuta glomerata. Proc. Iowa Acad. Sci. 41: 45-47 -. 1937. An addition to the bibliographies of the genus Cuscuta. Univ. Iowa Studies Nat. Hist. 17: 191-197. 1937.

Fedortschuk, W. 1931. Embryologische Untersuchungen von Cuscuta monogyna Vahl und C. epithymum L. Planta 14: 94-120.

Finn, W. W., and Safijovska, L. D. 1934. Zur Embryologie und Karyologie der Gattung Cuscuta. Bull. Jard. Bot. Kiew 16: 51-66.

Heitz, E. 1926. Der Nachweis der Chromosomen. Zeitschr. Bot. 18: 625-681.

Hooker, H. E. 1889. On Cuscuta Gronovii. Bot. Gaz. 14: 31-37.

Hurst, C. C. 1927. The mechanism of heredity and evolution. Eug. Rev. 19: 19-

Johri, B. M. 1935. The development of male and female gametophytes of Cuscuta reflexa Roxb. Proc. Indian Acad. Sci. Sec. B1 (6): 283-289. 1934/1935. (Abstr. 9314 in Biol. Abstr. 10: 1016. 1936.)

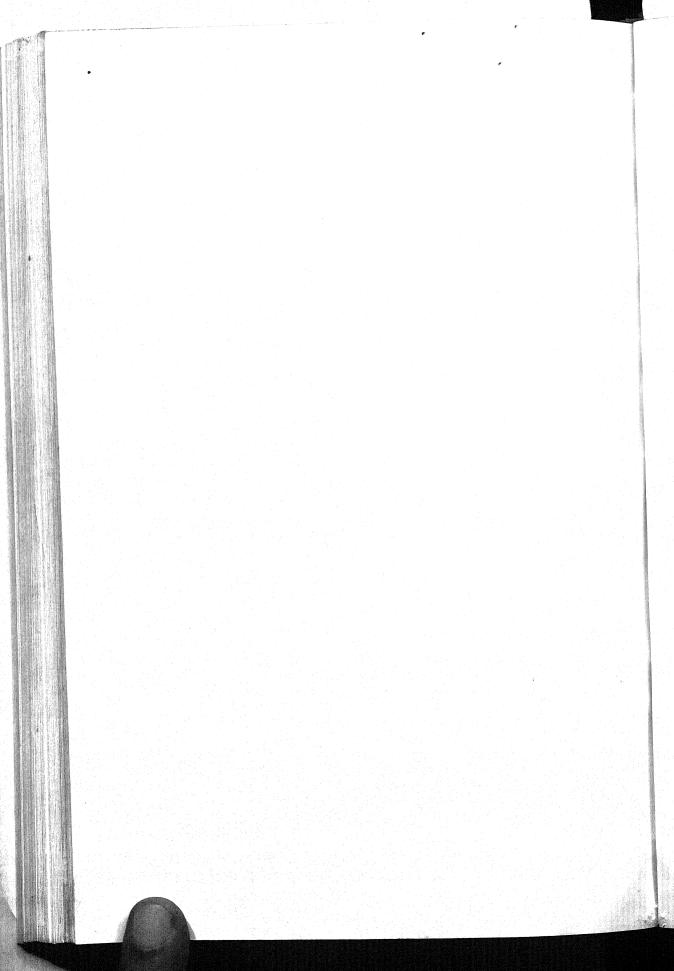
Kindermann, A. 1928. Haustorien-studien an Cuscuta-arten. Planta 5: 769-783.

Müntzing, A. 1936. The evolutionary significance of autopolyploidy. Hereditas

Peirce, G. J. 1893. On the structure of the haustoria of some phanerogamic parasites. Annals Bot. 7: 291-328.

Yuncker, T. G. 1920. Revision of the North American and West Indian species of Cuscuta. Ill. Biol. Monographs. 6: 1-141.

—. 1932. The genus Cuscuta. Bull. Torrey Bot. Club 18: 113-331.



New Florida Polypores

W. A. MURRILL (WITH FIVE FIGURES)

Central Florida abounds in polypores and the meeting of the northern and tropical species in this region never fails to interest the student. For example, Hexagona alveolaris fades out and H. daedalea becomes abundant; Daedalea quercina is nowhere to be seen, while D. ambigua is everywhere; our old northern friend, Elfvingia applanata, disappears but E. marmorata more than fills its place, while E. tornata creeps in sparingly from the tropics. Of Polyporus polyporus there is none, but P. arcularius springs from every buried stick, often associated with the brilliant sporophores of the tropical Pycnoporus sanguineus.

In this middle ground there must be some more or less local species, and a few of these have not heretofore been recognized. There are also a few rare enough or interesting enough to deserve special mention.

TRAMETES AMYGDALINA (Berk. & Rav.) Murrill

Polyporus amygdalinus Berk. & Rav.; Berk. Grevillea 1: 49. 1872.

My first real knowledge of this interesting species dates back about twenty years, when Dr. R. P. Burke sent it to me from Alabama. On Dec. 14, 1926, I first collected it at Gainesville; and on June 8, 1930, it was collected by Mr. Erdman West, Mycologist of the Florida Agricultural Experiment Station. These specimens were all old or dried when I first saw them, not exhibiting the true beauty of the fresh plant. In contrast to Laetiporus sulphureus, which it greatly resembles, the hymenophores may persist for months in situ, simply drying and fading, because the context is too tough to be attractive to insects or other enemies.

My first acquaintance with fresh plants was on Mar. 25, 1938, at Gainesville, when I found two fine hymenophores on old oak logs imbedded in wet soil in a low hammock. One had just reached maturity, while the other showed the milk-white tubes just forming. Both were about six by nine inches, two inches thick behind, with the tumid margin pale orange without and within, and the uneven, zonate surface umbrinous-fulvous near the margin and umbrinous behind. On first sight one could not fail to think of *L. sulphureus*; but, noting the dark color of the older portion of the pileus, further investigation would reveal the tough context and the difference in spore characters.

Elfvingia tornata (Pers.) Murrill

This common tropical species, closely allied to Ganoderma, has been

familiar to me for nearly forty years, but I was hardly prepared to find it in Central Florida. Although rare here, it has a wide range of hosts, extending even to orange and pine. The northerner would undoubtedly pass it by for the common *Elfvingia applanata*, but the surface is hard and the spores rough. Its favorite host in this region seems to be oak, either living or dead. I found it on orange in 1927, but Mr. Rhoads had collected it on this host two years before near Mt. Dora, and Dr. W. B. Tisdale on orange at Groveland, in 1932. My greatest surprise was at Green Cove Springs on Mar. 10, 1926, when I saw it growing on the stump of a slash pine that had been cut two years previously. The hymenophores were imbricate, the largest eight inches broad, and attached both to stump and roots.

Poria vincta (Berk.) Cooke

Described from Santo Domingo and found generally throughout tropical regions. At Gainesville it is fairly common on rotting logs of oak, magnolia, sweet gum and other broad-leaved trees, usually staining the wood orange. The northern mycologist would probably call it P. attenuata Pk. or P. eupora P. Karst. because of its rosy-isabelline color, but closer investigation reveals certain well-defined differences. I find the spores to be subglobose to broadly ellipsoid, smooth, hyaline, not guttulate, $3-4\times 2-3\mu$, about as in P. attenuata, but there are no cystidia.

SCUTIGER PERSICINUS (Berk. & Curt.) Murrill

This rare species, previously collected only in pine woods, was found by the author on June 14, 1938, at Gainesville, Fla., growing up between the roots near the base of a large live-oak. The following notes were made from the fresh specimens: Circular or irregular, somewhat lobed, 10–17 cm. broad, convex to depressed, rough, uneven, short-tomentose, white to rosy-isabelline, then bay or chestnut, blackening where bruised; margin tumid, white at first and remaining paler than the rest of the surface; context 2–3 cm. thick, zonate, white, changing to rosy-isabelline at once when cut and growing gradually darker; tubes decurrent, very short and small, white, becoming bay when bruised; stipe central, subcylindric, tomentose, white to umbrinous, darker with age or where bruised, about 8×4 cm.

Mr. Erdman West collected an older specimen under an oak near Gainesville on June 30, 1938, which measured 18×14 cm. It was irregularly elliptic with undulate margin, blackish on the disk, and the remainder either castaneous or atropurpureous; hymenium white with a suggestion of pink, becoming purple where bruised; spores copious, ellipsoid, smooth, hyaline, $5-7\times 3-4\mu$. It may be that this is an oak-loving species after all, probably attacking the roots of its host.

MICROPORELLUS MUTABILIS (Berk. & Curt.) Murrill, comb. nov.

Polyporus mutabilis Berk. & Curt. Ann Mag. Nat. Hist. II. 12: 433. 1853.

This species is common about Gainesville on fallen dead hardwood branches in low ground. It is thin, zonate, and regular or irregular, the spores being globose to ovoid, smooth, hyaline, uninucleate, not apiculate, about $3-4\times2.5-3$ μ . It is also common in tropical America.

M. dealbatus (Berk. & Curt.) Murrill, formerly considered rare, has been collected here frequently during recent months. It never grows on the top of dead branches, but springs up from decayed roots, and is an annual. Thicker, whiter, and more regular than M. mutabilis, it has spores that are irregularly broadly ellipsoid, conspicuously obliquely apiculate, smooth, hyaline, granular, thin-walled, and about $4 \times 3\mu$. Its range seems to be from central Florida through the Carolinas to Kentucky and Missouri.

AURANTIPORUS CROCEUS (Pers.) Murrill, comb. nov.

Polyporus croceus Pers. Obs. Myc. 1: 87. 1796.

Mr. Erdman West found a very handsome specimen of this rare and interesting species in a hammock near Gainesville, Fla., August 4, 1938 (F17982). It grew on the base of a giant living live-oak and was fully a foot wide. The surface was partly reddish-orange but mostly ochraceous; the context beautifully concentrically zonate; and the slender bright-orange tubes, over 2 cm. long, had just reached maturity. Near this tree, on the top of a dead oak log, another hymenophore was just beginning to form. In western North Carolina I found the fruit-bodies growing on the sides of oak and chestnut logs that were much decayed.

NIGROPORUS VINOSUS (Berk.) Murrill

Described from Santo Domingo and known also from Cuba and the State of Georgia. I have found it twice on pine wood and once on *Nyssa* in the vicinity of Gainesville, Fla.; and in July, 1938, Dr. G. F. Weber got a fine collection here of large specimens on a pine log. In the region about Gainesville it is frequent on dead logs of both hardwoods and pine. In the fresh condition it is easily confused with *Fomes subroseus*. Saccardo's "Sylloge," 1925, lists *Polyporus badius* Jungh. as a synonym.

Daedalea Westii sp. nov.

Pileo effuso-reflexo, 10-15 cm., tomentoso, ochraceo; poris 1-1.5 cm. longis, ochraceis, demum lacerato-dentatis.

Hymenophore effused-reflexed, simple or terraced-imbricate, growing in a narrow strip 15 cm. long or covering a spot on the trunk about 10 cm square;

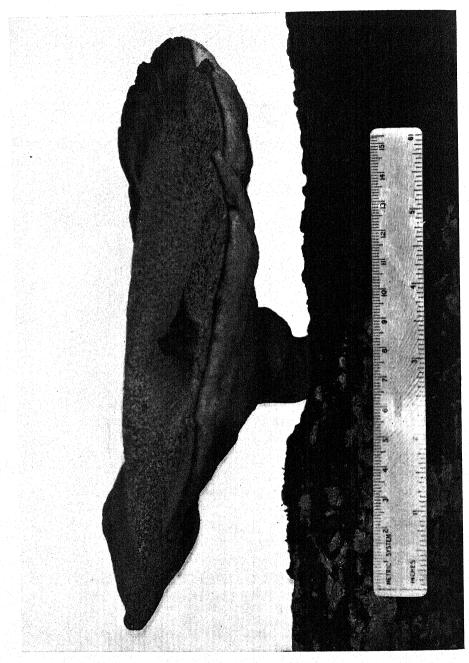


Fig. 1. Polyporus Westii Murrill, Type collection (F18100) X³, in Florida Agricultural Experiment Station Herbarium. Photo by A. S. Rhoads.

the reflexed portion triangular in section, $1-1.5 \times 2-3 \times 1-1.5$ cm., broader by confluence; surface tomentose, uneven, azonate, ochraceous to isabelline, margin undulate; context corky, homogeneous, white, about 5 mm. thick; tubes labyrinthiform, 1-1.5 cm. long, pallid within, edges obtuse, uneven, ochraceous, entire to lacerate-dentate; cystidia lacking; spores not found.

Type collected by Erdman West on living red cedar at Gainesville, Fla., Sept. 15, 1936 (No. F9190¹). Also collected by A. S. Rhoads on the same host at Clemson College, S. C., Aug. 27, 1936 (No. F8754). The latter collection represents an older stage in the development of the hymenophore and was used in making the description more complete. This species shows no resemblance to D. juniperina, which is ungulate in form and much larger, although the descriptions sound much alike.

Pyropolyporus taxodii sp. nov.

Pileo dimidiato, 6×10×2.5 cm., tomentuloso, zonato, fulvo; poris parvis, castaneo-umbrinis.

Pileus dimidiate, applanate, sessile by a rather broad base, solitary, $6\times10\times2.5$ cm.; surface densely tomentulose, uneven, zonate to sulcate, fulvous, bay on two of the very narrow bands, margin subacute, undulate to slightly lobed; context hard, woody, indistinctly concentrically zonate, about 1 cm. thick, ferruginous-ochraceous, subshining; tubes unstratified, reaching about 1 cm., 5 to a mm., thick-walled, isabelline-avellaneous within, mouths circular, edges entire, slightly glistening, castaneous-umbrinous; cystidia absent; spores not found but doubtless hyaline.

Type collected by A. S. Rhoads on a dead standing pond cypress at Gainesville, Fla., Nov. 11, 1923 (No. F16254). An attractive and interesting species found but once. Described from the dried specimen.

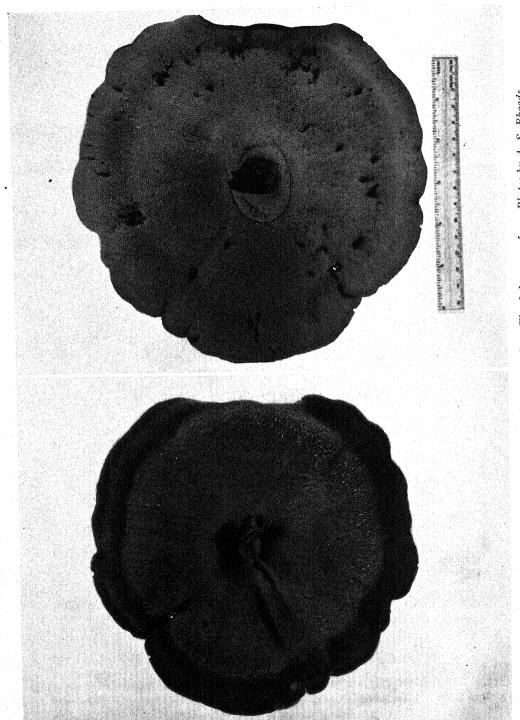
Polyporus Westii sp. nov.

Pileo infundibuliformi, 7-20 cm. lato, umbrino, hispidello, reticulato, lobato, 1-2 cm. crasso; tubulis angulatis, sporis hyalinis, $10-12\times4-5\mu$; stipite tomentoso, 4×3 cm.

Pileus somewhat irregular, infundibuliform, solitary, 7-20 cm. broad; surface umbrinous, finely hispid, reticulate; margin fuliginous, deflexed, lobed; context soft, white, sweet and nutty, 1-2 cm. thick; tubes decurrent, about 3 mm. long, 1 to a mm., white, angular, the edges very thin, entire; spores elongate, granular, smooth, hyaline, $10-12\times4-5\mu$; stipe pale-avellaneous, tomentose, umbrinous at the base, about 4×3 cm.

Type collected by West, Rhoads, Wodehouse and Murrill on the top of a rotten sweet-gum log in Planera Hammock, eleven miles northwest of

¹ All of the specimens cited in this paper are deposited in the Herbarium of the Florida Agricultural Experiment Station at Gainesville.



Figs. 2, 3. Polyporus Westii Murrill. Fig. 2, upper surface. Fig. 3, lower surface. Photos by A. S. Rhoads.

Gainesville, Fla., August 27, 1938 (F18100). Also collected by E. West near the same spot on a magnolia log, July 20, 1938 (F17913). A striking species decorated with sharp tufts of umbrinous fibrils and beautifully reticulate with brown lines.

Polyporus Rhoadsii sp. nov.

Pileo 6-8 cm. lato, squamuloso, ochraceo; poris parvis, ochraceis; sporis $6\times3\mu$; stipite subglabro, fulvo, $2-4\times1-1.5$ cm.

Pileus circular in general outline, depressed, about 6–8 cm. broad; surface conspicuously squamulose, dry, uniformly ochraceous, sometimes fulvous on drying; margin undulate to slightly lobed, fertile, concolorous, rarely deflexed in dried specimens; context white, soft-corky, homogeneous, 0.5–1 cm. thick; tubes short, decurrent, pallid to ochraceous or fulvous, mouths 3–4 to a mm., rather thin-walled, subcircular to angular, edges entire; spores pip-shaped, obliquely apiculate, smooth, hyaline, about $6\times3\mu$; setae and cystidia wanting; stipe usually central, subequal, often flattened, subglabrous, avellaneous or fulvous to subfuliginous, white and firm to corky within, about 2–4×1–1.5 cm.

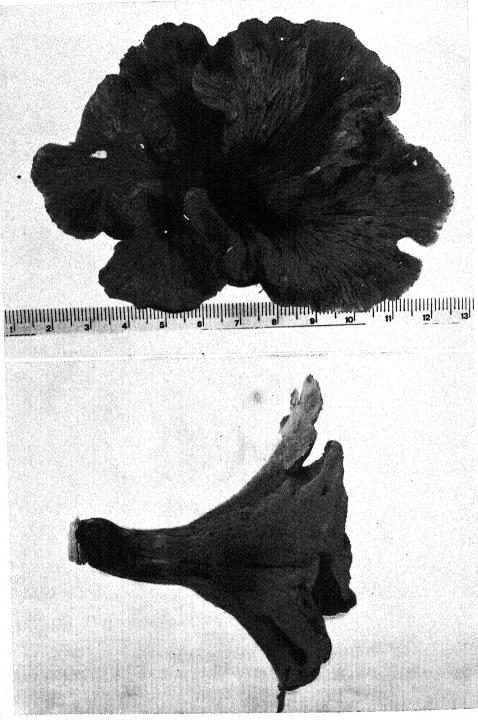
Type collected by A. S. Rhoads and Erdman West on an oak stump at Magnesia Springs, Alachua Co., Fla., August 16, 1935 (F8938). Also collected by Bratley and West on a rotten fallen pine branch at Magnesia Springs (F8931); and by J. R. Watson on buried wood near Gainesville (F8948). This last specimen is multiplex, two stems having grown together and the caps being quite irregular because of the union. The author found two sweet-gum logs covered with old hymenophores of this species on June 5, 1938 (F16327). In this aged condition the caps were virgate rather than squamulose, suggesting P. virgatus, a tropical species. Mr. West collected a fresh specimen on oak, June 19, 1938 (F16379), which yielded an abundance of spores.

Polyporus Arnoldae sp. nov.

Pileo umbilicato, caespitoso, 4-6 cm. lato, roseo-isabellino; tubulis praeminutis, decurrentibus; sporis ellipsoideis, $5-6\times3-4\mu$; stipite pallido, glabro, $1.5-2\times0.5-0.8$ cm.

Pileus circular or subcircular, umbilicate, cespitose, 4–6 cm. broad; surface hygrophanous, subglabrous, pale rosy-isabelline; margin very thin, subentire or undulate, even, straight, sodden-white for 1 cm., eroded and slightly fissile with age, not ciliate; context thin, pallid, with pleasant odor and taste; tubes minute, thin-walled, decurrent, stramineous, the edges becoming eroded; spores ellipsoid, smooth, hyaline, copious, $5-6\times3-4\mu$; stipe tapering downward, glabrous, smooth, solid, whitish with an avellaneous tint, $1.5-2\times0.5-0.8$ cm.

Type collected by E. West, Lillian Arnold and W. A. Murrill on a



Figs. 4, 5. Polyporus Rhoadsii Murrill. Fig. 4, slightly enlarged to show virgate surface. Fig. 5, about natural size. Photos by A. S. Rhoads.

19387

hardwood log in Planera Hammock, eleven miles northwest of Gainesville, Fla., July 16, 1938 (F17863). Suggesting P. albiceps Peck in some ways but deeply umbilicate, very thin, and not pure-white.

Abortiporus subabortivus sp. nov.

Pileo convexo-depresso, tomentoso, roseo-isabellino, 10-15 cm. lato; tubulis angulatis, brevibus, albis; sporis subglobosis, asperulatis, $5-6\mu$; stipite subglabro, pallido, $4-6\times 1-2.5$ cm.

Convex to depressed, gregarious to subcespitose, 10–15 cm. broad; surface spongy, shaggy-tomentose, rosy-isabelline, somewhat zonate, margin thin, paler, broadly sterile; context thin, duplex, the upper layer loosely woven and concolorous, the lower firm, white, tough and flexible, odor pleasant, taste like wet wood; tubes decurrent, about 2 mm. long, 2–3 to a mm., angular, very thin-walled, edges mostly entire, white, usually turning dark-brown when dried; spores subglobose, thin-walled, hyaline, granular, minutely asperate, copious, $5-6\mu$; stipe subequal, often irregular, firm, corky, subglabrous, subconcolorous or pallid, often radicate, about $4-6\times1-2.5$ cm.

Type collected by West and Murrill on roots in Sanchez Hammock, eleven miles northwest of Gainesville, Florida, July 23, 1938, (F17955). Also collected by West and Murrill on roots in Kelley's Hammock, ten miles northwest of Gainesville, July 19, 1938 (F17933). In this latter collection the tubes were entirely sterile and there were also three aborted hymenophores. The species resembles A. distortus, but has a shaggy surface, a different context, and a firmer stem. The spores, instead of being usually ellipsoid and always smooth and uninucleate, are sugblobose, granular and minutely asperate. The large sporophores spring from the ground over buried roots, to which they are attached.

Hahalopilus subrutilans sp. nov.

Pileo dimidiato, saepe effuso-reflexo, ochraceo, tomentoso; poris albis, minutis; sporis ellipsoideis, $3.5 \times 2.5 \mu$.

Pileus imbricate, sessile, dimidiate, convex, often resupinate, the reflexed portion $2-3\times3-6\times1-1.5$ cm.; surface ochraceous, sometimes fulvous on drying, conspicuously tomentose, azonate; margin thin, entire or lobed, subconcolorous, not deflexed on drying; context thin, soft-corky, homogeneous, isabelline; tubes slender, white, about 5 mm. long, mouths minute, 6 to a mm., slightly angular, the edges entire, thin, concolorous; spores ellipsoid, regular, smooth, hyaline, $3.5\times2.5\mu$.

Type collected by A. S. Rhoads on a fallen branch of *Magnolia glauca* at Hatchet Creek near Gainesville, Fla., Oct. 16, 1927 (No. F8750). This species is paler than *H. rutilans*, more inclined to be resupinate, and has much smaller tubes. Both species are rare in this locality.

Coriolopsis Tisdaleana sp. nov.

Pileo dimidiato, $3\times6\times0.3-1$ cm., sulcato, tomentoso, ochraceo-ferruginoso; tubulis magnis, subhexagonis, sporis hyalinis, $10\times4\mu$.

Pileus gregarious, dimidiate, conchate, about $3\times6\times0.3-1$ cm.; surface narrowly concentrically sulcate, conspicuously tomentose, ochraceous-ferruginous, fulvous behind; margin straight, rather thin, ochroleucous, entire to undulate or slightly lobed, with a narrow white sterile border below; context tough, flexible, isabelline, 2–3 mm. thick, odor and taste not characteristic; hymenium pallid, then avellaneous-isabelline, unchanged on drying; tubes large, hexagonal or subhexagonal, 1–2 to a mm., the edges firm, medium thick and entire; spores oblong-ellipsoid, smooth, hyaline, granular, copious, about $10\times4\mu$; cystidia none.

Type collected by West and Murrill on a dead hardwood log in Sanchez Hammock, eleven miles northwest of Gainesville, Florida, July 23, 1938 (F17975). Dedicated to Dr. W. B. Tisdale, Chief Plant Pathologist in the Experiment Station.

Trametes Humeana sp. nov.

Pileo dimidiato, 7-10 cm. lato, albo, anisato; sporis ellipsoideis, hyalinis, $3\times 2\mu$.

Pileus dimidiate to reniform, narrowly to broadly sessile, rarely imbricate, $5-7\times7-10\times1.5-3$ cm; surface anoderm, opaque, uneven, pruinose, slightly zonate at times, white to partly rosy-avellaneous, slightly rosy-avellaneous behind in young specimens becoming darker with age; margin thin, entire or undulate, very narrowly sterile; context tough, fibrous, concentrically zonate, pallid, with nutty flavor and a strong odor of anise, about 7 mm. thick, becoming slightly rosy-avellaneous after being cut; hymenium even, white, rosy-avellaneous where bruised; tubes about 7 mm. long, white within, slightly rosy-avellaneous when cut, mouths angular, 2 to a mm., at times irregularly elongate and daedaleoid, edges thin, entire; spores broadly ellipsoid, smooth, hyaline, uniguttulate, about $3\times2\mu$.

Type collected by West and Murrill on a dead oak log under hardwood trees in Sugarfoot Hammock, near Gainesville, Fla., August 4, 1938 (F17978). Suggesting Tyromyces Spraguei (Berk. & Curt.) Murrill, but differing in color, context, odor and size of spores. Dedicated to Dr. Harold H. Hume, Director of Research at the Florida Agricultural Experiment Station.

Tramates subcubensis sp. nov.

Pileo applanato, dimidiato, lato, sulcato, albo vel cremeo; tubulis 1 cm. longis; sporis $6\times3\mu$, cystidiis nullis.

Pileus dimidiate, applanate, 6-10×10-20×1-2 cm.; surface anoderm, uneven, rugose, somewhat sulcate, subglabrous, white or cremeous, margin

entire to lobed, concolorous, ochraceous behind; context white to yellowish, soft, punky, with the odor of anise, 5–10 mm. thick; tubes corky, 4 to a mm., reaching at least 1 cm. long, mouths subcircular, entire, pallid to cremeous; spores elongate, smooth, hyaline, copious, about $6\times3\mu$; cystidia none.

Type collected by W. A. Murrill on an oak log at Magnesia Springs, Alachua Co., Fla., May 22, 1938 (F16240). Also collected by the author on an oak log at Gainesville, Fla., April 6, 1938 (F16191). Suggesting T. cubensis (Mont.) Sacc. but having much longer tubes, an anoderm surface, and elongate spores.

Tyromyces avellaneialbus sp. nov.

Effuso-reflexo, avellaneo; poris parvis, albis, angulatis; sporis subglobosis, 3μ .

Effused for several centimeters with narrowly reflexed margin, somewhat imbricate, the reflexed portion $1-2\times2-4\times0.2-0.7$ cm., wider by confluence; surface dry, uneven, pubescent, azonate, avellaneous, margin even, lobed, concolorous; context milk-white or pallid, unchanging, 2-3 mm. thick, taste astringent, somewhat like that of the toothache tree; tubes snow-white, 2-3 mm. long, mouths circular and thick-walled to angular and thinner-walled, glistening, white, with a faint greenish tint, 3-4 to a mm., edges entire; spores very copius, subglobose to broadly ovoid, smooth, hyaline, uniguttulate, about 3μ long; cystidia none.

Type collected by W. A. Murrill on a sweet-gum log at Newnan's Lake, Alachua County, Florida, May 1, 1938 (F15621). A very distinct species, found but once. The name refers to the uniformly avellaneous surface and the milk-white hymenium.

Coriolus membranaceus taxodii var. nov.

Pileo dimidiato, imbricato, zonato, pallido et fumoso; poris albis, parvis; sporis $4-5 \times 2.5\mu$.

Pileus dimidiate, densely imbricate, $3-5\times5-10\times0.2-0.3$ cm., often laterally confluent; surface zonate, pubescent to glabrous, usually rough behind and plicate with age, whitish or cremeous with fumosous zones; margin thin, fumosous, entire to undulate or lobed; context thin, white, tough; tubes 1 mm. long, white, cremeous on drying; mouths glistening, angular, thin-walled, entire, 3-4 to a mm., often irregular and dentate with age; cystidia none; spores copius, oblong-ellipsoid, smooth, hyaline, nonguttulate, about $4-5\times2.5\mu$.

Type collected by W. A. Murrill on dead cypress logs at Newnan's Lake, Alachua County, Florida, April 24, 1938 (F8598). Growing in very densely imbricated masses on the ends of logs lying in boggy places. The peculiar dark-gray color of the zones and margin is distinctive in younger stages but may disappear with age. Black cypress is the only host.

Coriolus subabietinus sp. nov.

Effuso-reflexo, 1-5 cm. lato, fibrilloso, pallido; poris albidis, minutis,

Effused in patches 1-5 cm. broad, narrowly reflexed, margin incurved on drying; the reflexed portion very thin, densely fibrillose, even, pallid, undulate to lobed; context watery-pallid, membranous; tubes short, less than 1 mm., pallid within, mouths whitish to cremeous, angular, about 5 to a mm., edges entire, becoming rather thin at maturity; cystidia none; spores not found.

Type collected by Erdman West and W. A. Murrill on a pine log at Gainesville, Florida, October 24, 1932 (F8746). The tubes are too small for C. abietinus. A few spores were found which were globose, smooth, hyaline, $3-4\mu$, but their origin was uncertain.

Coriolus sublimitatus sp. nov.

Pileo imbricato, 2-4 cm. lato, sulcato, tomentoso, pallido; poris albis,

minutis, angulatis.

Pileus imbricate, flabelliform, sessile, thin, coriaceous, flexible, 2-4 cm. broad; surface concentrically sulcate, tomentose, pallid to grayish; margin white to isabelline, subentire, thin, broadly sterile, incurved on drying; context thin, fibrous, firm, pallid; tubes short, white, mouths minute, angular, edges thin, subentire; spores not found; cystidia wanting.

Type collected by A. S. Rhoads on a dead citrus trunk at Indianola, Florida, January 4, 1929 (F8741), This species differs from C. limitatus in being densely imbricate and in having white instead of reddish tubes.

Coriolus tenuispinifer sp. nov.

Pileo conchato, 2 cm. lato, albo, tomentoso, sulcato; poris parvis, albidis; cystidiis longis, rubro-brunneis, $100-125\times 3-6\mu$.

Pileus very thin, conchate, sessile, gregarious, not imbricate, reaching 1×2 cm.; surface uniformly white and villose-tomentose, concentrically sulcate, margin subentire, deflexed on drying; context very thin, white; tubes short, irregular, angular, thin-walled, white to isabelline, about 4–5 to a mm., edges soon becoming dentate; spores not found; cystidia abundant, long, slender, straight or flexuous, dark reddish-brown, slightly tapering upward from a slightly enlarged base, acute but not sharp at the tip, which is usually subhyaline, $100-125\times 3-6\mu$.

Type collected by W. A. Murrill, G. F. Weber and Erdman West on a decayed fallen oak branch in mixed woods at Gainesville, Florida, December 1, 1926 (F8755). Found but once. Resembling C. depauperatus (Pat.) Murr., but having slender spines on the hymenium.

Fomitiporia punctatiformis sp. nov.

Late effuso, 7 mm. crasso, margine isabellino, adnato, 1 cm. lato; poris minutis, avellaneo-umbrinis.

Broadly effused, extending many centimeters along branches, inseparable, elongate-elliptic, rigid, about 7 mm. thick; margin isabelline to latericious, and finally bay or chestnut with age, adnate, rather thick, subglabrous to glabrous, about 1 cm. broad; context inconspicuous; hymenium smooth, convex, somewhat glistening, several times indistinctly stratified; tubes about 7 mm. long, whitish-stuffed, avellaneous-umbrinous within, mouths regular, minute, circular, 6 to a mm., edges thick, entire, avellaneous-umbrinous; cystidia none; young spores globose, smooth, hyaline, $2-3\mu$.

Type collected by A. S. Rhoads on a dead fallen oak branch in a hammock west of Cocoa, Fla., June 10, 1937 (F12073). Suggesting F. punctata, but the tubes are not distinctly stratified.

Poria alachuana sp. nov.

Effuso, 2-4 mm. crasso, margine albo; poris albis, angulatis, parvis; sporis ovoideis, $3-4\times 2-3\mu$.

Effused, continuous, inseparable, 2-4 mm. thick, often reviving and stratified; margin thin, milk-white, mostly evanescent; context thin, white, scarcely apparent in age; hymenium rather uneven, somewhat glistening, white to lemon-yellow; tubes angular, irregular, thin-walled, entire, 4-5 to a mm., or larger by confluence; spores ovoid, smooth, hyaline, $3-4\times2-3\mu$; cystidia none.

Type collected by W. A. Murrill on a decayed hardwood log in Prairie Creek Hammock, Alachua Co., Fla., Mar. 27, 1938 (F16157). Found but once. In older dried specimens the hymenium cracks into areas one or two centimeters long.

Poria Floridae sp. nov.

Effuso, 2-3 mm. crasso, margine albo; poris pallidis, minutis, angulatis;

sporis globosis, 3μ .

Effused for several centimeters, continuous, inseparable, about 2–3 mm. thick; margin inconspicuous, delicate, milk-white, mostly disappearing with age; context white, thin, scarcely apparent in old specimens; hymenium fairly even, dull-white to dull-pale-rosy-isabelline; tubes minute, nearly regular at first, thin-walled, angular, entire, about 7–8 to a mm., becoming more or less unequal, elongate at times, or enlarging by the splitting of the walls; spores globose, smooth, hyaline, 3μ ; cystidia none.

Type collected by W. A. Murrill on a hardwood log in a low hammock at Gainesville, Fla., Mar. 25, 1938 (F16121). Found but once. Some parts of the hymenium show one or two indistinct lines of stratification, indicating seasonal growth.

Poria ferruginicincta sp. nov.

Late effuso, 1–1.5 cm. crasso, margine ferrugineo; poris albis ad subbrunneis, minutis; sporis subglobosis, 5μ .

Widely and almost continuously effused, inseparable, about 1–1.5 cm. Widely and almost continuously effused, inseparable, about 1–1.5 cm. thick; margin narrow, undulate, ferruginous; context white, thin, scarcely apparent at maturity; hymenium uneven, white to brownish-discolored; tubes apparent at maturity; hymenium uneven, white to brownish-discolored; tubes apparent at maturity; hymenium uneven, white to brownish-discolored; tubes regular, thin-walled, angular, entire, about 5–6 to a mm., becoming quite irregular in shape and size; spores subglobose, smooth, hyaline, about 5μ ; cystidia none.

• Type collected by Erdman West and W. A. Murrill on an oak log at Gainesville, Fla., Nov. 7, 1932 (F9127). A large, coarse, more or less undulate species, white when fresh but brown in the herbarium.

Poria holoseparans sp. nov.

Effuso interrupto, 1–2 mm. crasso, margine albo; poris albidis, valde minutis, angulatis; sporis globosis, $3-4\mu$.

Effused in patches several centimeters long and wide, not continuous, separable, 1–2 mm. thick; margin narrow, milk-white; context white, thin but substantial and remaining plainly visible; hymenium very even, sodden-white, whiter and somewhat glistening at maturity and becoming dirty-ochraceous with age; tubes minute, angular, regular, thin-walled, entire, about 10 to a mm., sometimes larger; spores globose, smooth, hyaline, uniguttulate, $3-4\mu$; cystidia none.

Type collected by W. A. Murrill on a wet hornbeam log in a low hammock at Gainesville, Fla., Apr. 8, 1938 (F16186). The hymenophores may curl up in drying and entirely separate from the substratum, suggesting a resupinate form of a pileate polypore.

Poria lacteimicans sp. nov.

Effuso, 1 mm. crasso, margine albo; poris albis, angulatis, valde minutis;

sporis globosis, 2μ . Effused for several centimeters, continuous, inseparable, about 1 mm. thick; margin very thin and delicate, milk-white; context thin, white, scarcely noticed in age; hymenium even, not stratose, glistening, milk-white, slightly brownish where bruised; tubes short, regular, angular, thin-walled, entire, very minute, about 10 to a mm.; spores copious, globose or subglobose, smooth, hyaline, 2μ ; cystidia none.

Type collected by W. A. Murrill on an oak log at Gainesville, Fla., Apr. 9, 1938 (F16199). Found but once. A dainty white species with very glistening hymenium.

NEW COMBINATIONS

For the convenience of those using Saccardo's nomenclature, the following new combinations are made:

ABORTIPORUS SUBABORTIVUS = Polyporus subabortivus CORIOLOPSIS TISDALEANA = Polyporus Tisdaleanus CORIOLUS SUBABIETINUS = Polystictus subabietinus CORIOLUS SUBLIMITATUS = Polystictus sublimitatus CORIOLUS TENUISPINIFER = Polystictus tenuispinifer FOMITIPORIA PUNCTATIFORMIS = Poria punctatiformis HAPALOPILUS SUBRUTILANS = Polyporus subrutilans PYROPOLYPORUS TAXODII = Fomes taxodii TRAMETES HUMEANA = Polyporus Humeanus TRAMETES SUBCUBENSIS = Polyporus subcubensis TYROMYCES AVELLANEIALBUS = Polyporus avellaneialbus

HERBARIUM, FLORIDA AGRICULTURAL EXPERIMENT STATION GAINESVILLE, FLA.

INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

This index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the Index may be addressed to the Treasurer of the Torrey Club.

- Abbe, E. C. Studies in the phylogeny of the Betulaceae. II. Extremes in the range of variation of floral and inflorescence morphology. Bot. Gaz. 99: 431-469. f. 1-100. Mr 1938.
- Adams, J. W. New stations for Lophotocarpus spongiosus in southern New Jersey. Bartonia 19: 42-43. 8 Mr 1938.
- Adams, J. W. Populus heterophylla in southern New Jersey. Bartonia 19: 45-46. 8 Mr 1938.
- Alsberg, C. L. Structure of the starch granules. Plant Physiol. 13: 295-330. Ap 1938.
- Ames, O. Studies in Stelis. VII. Harvard Univ. Bot. Mus. Leafl. 6: 13-36. illust. Je 1938.
- Ark, P. A., Tompkins, C. M. & Smith, R. E. A bacterial bud and stem rot of recket larkspur. Phytopathology 28: 281-283. Ap 1938.
- Ark, P. A. & Tompkins, C. M. A soft-rot bacteriosis of pumpkin fruits. Phytopathology 28: 350-355. f. 1-4. My 1938.
- Bailey, L. H. The garden of pinks, i-viii. 1-142. pl. 1-44. Macmillan Book Co. New York. 1938.
- Bennett, J. R. & Skoog, F. Preliminary experiments on the relation of growth-promoting substances to the rest period in fruit trees. Plant Physiol. 13: 219-226. f. 1. Ap 1938.
- Bliss, D. E. Two new species of *Omphalia* which cause decline disease in date palms. Mycologia 30: 313-326. f. 1-10. My-Je 1938.
- Bold, H. C. Notes on Maryland algae. Bull. Torrey Club 56: 292-301. pl. 6, 7. My 1938.
- Bonner, J. & English, J. A chemical and physiological study of traumatin, a plant wound hormone. Plant Physiol. 13: 331-348. f. 1-3. Ap 1938.
- Borg, J. Cacti. v-xi. 1-419. illust.+frontisp. The Macmillan Co., New York. 1937.
- Brown, H. P. Trees of northeastern United States—native and naturalized. 7–490. *illust*. Christopher Publ. House, Boston. 1938.

Brown, N. A. The tumor disease of oak and hickory trees. Phytopathology 28: 401-411. f. 1-4. Je 1938.

Buell, M. F. Embryogeny of *Acorus calamus*. Bot. Gaz. 99: 556-568. f. 1-19. Mr 1938.

Buell, H. F. A community of blue-green algae in a Minnesota pond. Ecology 19: 224–232. f. 1, 2. Ap 1938.

Burkhart, L. Ammonium nutrition and metabolism of etiolated seedlings. Plant Physiol. 13: 265-293. f. 1-11. Ap 1938.

Camp, W. H. Studies in the Ericales. III. The genus Leio-phyllum. Bull. Torrey Club. 65: 99-104. F 1938.

Carolus, R. L. Effect of certain ions, used singly and in combination, on the growth and potassium, calcium, and magnesium absorption of the bean plant. Plant Physiol. 13: 349-363. f. 1-2. Ap 1938.

Chester, F. D. A bacteriosis of dahlia, Erwinia cytolytica. Phytopathology 28: 427–432. Je 1938.

Clayton, E. E., Smith, H. H. & Foster, H. H. Mosaic resistance in *Nicotiana tabacum* L. Phytopathology 28: 286, 287. f. 1. Ap 1938.

Clinton, G. P. & Zunkel, G. L. Notes on some Ustilaginales from India. Mycologia 30: 280, 281. My-Je 1938.

Chrysler, M. A. The winter buds of Brasenia. Bull. Torrey Club 65: 277-283. f. 1-11. My 1938.

Clute, W. N. Fruiting of Calycanthus. Am. Bot. 44: 47-49.

illust. Ap 1938.

Cochran, L. C. & Smith, C. O. Asteroid spot, a new virosis of the peach. Phytopathology 28: 278-281. f. 1, 2. Ap 1938.

Cooper, G. O. Cytological investigations of *Pisum sativum*. Bot. Gaz. 99: 584-591. f. 1-28. Mr 1938.

Cooper, W. C. Hormones and root formation. Bot. Gaz. 99: 599-614. Mr 1938.

Cory, V. L. Notes on Ephedra in Texas. Rhodora 40: 215-218.

My 1938.

Crandell, B. S. & Hartley, C. Phytophthora cactorum associated with seedling diseases in forest nurseries. Phytopathology 28: 358-360. My 1938.

Dahlgren, B. E. Coffee. Field Mus. Nat. His. Leafl. 22: 1-43.

illust. 1938.

Darlington, C. D. Recent advantages in cytology. i-xvi. 1-671. pl. 1-16+f. 1-160. Blakiston's Son & Co. Philadelphia 1937. Second Edition.

Davis, B. H. The Cercospora leaf spot of rose caused by Mycosphaerella rosicola. Mycologia 30: 282-298. f. 1-7. My-Je 1938.

- Denney, F. E. & Miller, L. P. Suggestions for standardizing the ethylene chlorohydrin treatment for inducing sprouting of recently-harvested intact potato tubers. Contr. Boyce Thompson Inst. 9: 283-292. Ap-Je 1938.
- Donat, A. Notas fitogeograficas Tetrachondra patagonica en Chile. Rev. Chilena Hist. Nat. 37: 104-106. 1933.
- Drouet, F. Notes on Myxophyceae. I-IV. Bull. Torrey Club 65: 285-292. My 1938.
- Drouet, F. Oscillatoriaceae of southern Massachusetts. Rhodora 40: 221-241. Je 1938.
- DuBuy, H. G. & Olson, R. A. Protoplasmic streaming, electric potentials and growth in coleoptiles of *Triticum* and *Avena*. Science 87: 490-491. 27 My 1938.
- Dunegan, J. C. The rust of stone fruits. Phytopathology 28: 411-427. f. 1, 2. Je 1938.
- Dyal, S. C. Valerianella in North America. Rhodora 40: 185-212 pl. 492-494. My 1938.
- Earle, E. C. Juncus Roemerianus in Talbot County, Maryland. Bartonia 19: 45. 8 Mr 1938.
- Eggler, W. A. The maple-basswood forest type in Washburn County, Wisconsin. Ecology 19: 243-263. f. 1-4. Ap 1938.
- Fassett, N. C. Spring flora of Wisconsin. 1-176. f. 1-393. Univ. of Wisconsin. 1938.
- Featherly, H. I. A new *Triodia* from Oklahoma. Rhodora 40: 243, 244. Je 1938.
- Fender, F. S. The flora of Seven Mile Beach, New Jersey. Bartonia 19: 23-41. 8 Mr 1938.
- Fernalk, M. L. Anaphalis margaritaceae again. Rhodora 40: 218, 219. My 1938.
- Flemion, F. A rapid method for determining the viability of dormant seeds. Contr. Boyce Thompson Inst. 9: 339-352. f. 1. My-Je 1938.
- Glowenke, S. L. A locality for *Hierochloe odorata* in Pennsylvania. Bartonia 19:43, 44. 8 Mr 1938.
- Glowenke, S. L. Occurrence and seed production of Froelichia floridana. Bartonia 19: 47. 8 Mr 1938.
- Goddard, D. R. & Smith, P. E. Respiratory block in the dormant spores of *Neurospora tetrasperma*. Plant Physiol. 13: 241-264. f. 1-5. Ap 1938.
- Goldberg, E. Root and shoot production induced in cabbage by Beta (3) indole-acetic acid. Science 87: 511-512. 3 Je 1938.
- Griffiths, A. E. Observations on the germination of lettuce seed. Contr. Boyce Thompson Inst. 9: 329-338. f. 1-5. My-Je 1938.

- Grout, A. J. Moss flora of North America—north of Mexico. (Leskea and Pseudoleskea by A. J. Sharp; Fontinalaceae by W. H. Welch, Au 1934; Erpodiaceae by W. C. Steere; Splachnaceae by G. Sayre.) Publ. by author, Vermont, My 1935.
- Guthrie, J. D. Phosphatase activity of the juice of the plant tissue following treatment with ethylene chlorohydrin. Contr. Boyce Thompson Inst. 9: 293-297. My-Je 1938.
- Hagelstein, R. Common species of the Mycetozoa. Torreya 38: 25-41. pl. 1, 2. Mr-Ap 1938.
- Hagelstein, R. Notes on the Mycetozoa—II. Mycologia 30: 336-353. My-Je 1938.
- Hammer, K. C. Correlative effects of environmental factors on photoperiodism. Bot. Gaz. 99: 615-629. Mr 1938.
- Harper, F. & Leeds, A. N. A supplementary chapter on Franklinia alatamaha. Bartonia 19: 1-13. f. 1. 8 Mr 1938.
- Harter, L. L. A root rot of peas caused by Fusarium coeruleum. Phytopathology 28: 432–438. f. 1. Je 1938.
- Hollingshead, M. H. Ferns of the New Jersey Pine Barrens. Torreya 38: 63-66. My-Je 1938.
- Holmes, F. O. Inheritance of resistance to tobacco-mosaic disease in *Browallia*. Phytopathology 28: 363-369. f. 1, 2. My 1938.
- Holton, C. S. A new pathogenically distinct race derived from a cross between *Tilletia tritici* and *T. levis*. Phytopathology 28: 371, 372. My 1938.
- Hopp, H. Sporophore formation by Fomes applanatus in culture. Phytopathology 28: 356-358. f. 1. My 1938.
- Hill, A. F. Castilla or Castilloa? Harvard Univ. Bot. Mus. Leafl. 5: 161-172. Mr 1938.
- Hulten, E. Flora of the Aleutian Islands and westernmost Alaska Peninsula with notes on the flora of Commander Islands. Stockholm. 5-397. pl. 1-16. 1937.
- Humphrey, C. J. Notes on some Basidiomycetes from the Orient. Mycologia 30: 327-335. f. 1-3. My-Je 1938.
- Ireland, J. C. Sorghum characters grouped by multiple correlations. Jour. Agr. Res. 56: 707-710. My 1938.
- Jackson, L. W. R. Winter injury of Buxus sempervirens. Phytopathology 28: 372-374. f. 1. My 1938.
- Jenkins, A. E. New records of anthracnose of Labrador tea (Elsinoë ledi) and of snowberry (Sphaceloma symphoricapri). Phytopathology 28: 374, 375. f. 1. My 1938.
- Jenkins, A. E. & McWhorter, F. P. Additional records of rose anthracnose in the United States. Phytopathology 28: 360-363. f. 1. My 1938.

- Jepson, W. L. A flora of California. 2: 1-16. 17 S; 17-176. f. 128-162. 15 S; 177-336. f. 162-206. 20 J1; 337-648. f. 206-279. frontisp. 17 S 1936.
- **Johnson, H. W.** Further determinations of the carbohydratenitrogen relationship and carotene in leaf-hopper-yellowed and green alfalfa. Phytopathology **28**: 273–277. f. 1. Ap 1938.
- Karling, J. S. Two new operculate chytrids. Mycologia 30: 302-312. f. 1-37. My-Je 1938.
- Keck, D. D. Studies in *Penstemon*. VI. The Section Aurator. Bull. Torrey Club 65: 233-255. Ap 1938.
- Koehler, B. & Holbert, J. R. Combating corn diseases in Illinois. Illinois Agr. Exp. Sta. Circ. 484: 1-35. f. 1-22. Mr 1938.
- Langman, I. K. A third station in Pennsylvania for *Potentilla tridentata*. Bartonia 19:48. 8 Mr 1938.
- Leach, L. D. & Davey, A. E. Determining the sclerotial population *Sclerotium rolfsii* by soil analysis and predicting losses of sugar beets on the basis of these analyses. Jour. Agr. Res. 56: 619-631. 15 Ap 1938.
- Leach, J. G., Krantz, F. A., Decker, P. & Mattson, H. The measurement and inheritance of scab resistance in selfed and hybrid progenies of potatoes. Jour. Agr. Res. 56: 843-853. f. 1. Je 1938.
- Lemmon, R. S. Propagation of the native species of *Chimaphila*. Jour. N. Y. Bot. Gard. 39: 129, 130. Je 1938.
- Lemmon, W. P. Notes on a study of the southeastern azaleas with description of two new species. Bartonia 19: 14-17. 8 Mr 1938.
- Leukel, R. W., Faris, J. A., Tapke, V. F. & Rodenhiser, H. A. Wheat smuts and their control. U. S. Dept. Agr. Farm Bull. 1711: 1-18. f. 1-10. 1938.
- Levine, M. N. & Smith, D. C. Comparative reaction of oat varieties in the seedling and maturing stages to physiologic races of *Puccinia graminis avenae*, and the distribution of these races in the United States. Jour. Agr. Res. 55: 713-729. 15 N 1937.
- Mackinney, G. Applicability of Kundt's rule to chlorophyll. Plant Physiol. 13: 427-430. f. 1. Ap 1938.
- Marshall, W. T. Two new species of Echinocereus. Jour. Cactus & Succ. Soc. Am. 9: 159-161. illust. Ap 1938.
- McCool, M. M. & Johnson, A. N. Nitrogen and sulphur content of leaves of plants with and at different distances from industrial centers. Contr. Boyce Thompson Inst. 9: 371-380. My-Je 1938.

McKee, M. C. & Lobb, D. E. Formation of nitrate in detached green leaves of swiss chard and tomato. Plant Physiol. 13: 407-412. f. 1, 2. Ap 1938.

McNew, G. L. Dispersion and growth of bacterial cells suspended in agar. Phytopathology 28: 387-401. f. 1-3. Je

1938.

McWhorter, F. P. "Broken" tulips are diseased. Florists Exch.

90²⁴: 15, 18. 11 Je 1938.

McWhorter, F. P. The antithetic virus theory of tulip-breaking. Ann. Appl. Biol. 25²: 254-270. pl. 8, 9. My 1938.

Mesbaum, C. J. & Keitt, G. W. A cytological study of host-parasite relations of *Venturia inaequalis* on apple leaves. Jour. Agr. Res. 56: 595-616. pl. 1-3+f. 1-4. 15 Ap 1938.

Mitchell, J. W. & Hammer, C. L. Stimulating effect of Beta (3) indole acetic acid on synthesis of solid matter by bean plants. Bot. Gaz. 99: 569-583. f. 1-5. Mr 1938.

Moldenke, C. E. Ueber die in altägyptischen Texten erwähnten Bäume und deren Verwerthung. 1–149. illust. Leipzig. 1886.

Molisch, H. The longevity of plants. 1–226. f. 1–38. 1928. Published by the translator, Dr. E. H. Fulling, 1938.

Moose, C. A. Chemical and spectroscopic analysis of phloem exudate and parenchyma sap from several species of plants. Plant Physiol. 13: 365–380. f. 1–3. Ap 1938.

Moss, E. H. Longevity of seed and establishment of seedlings in species of *Populus*. Bot. Gaz. 99: 529-542. Mr 1938.

Munz, P. S. Studies in Onagraceae. XI. A revision of the genus Gaura. Bull. Torrey Club 65: 228. f. 1-8. Ap 1938. (concluded).

Murphy, D. M. & Pierce, W. H. A mosaic-resistant small red bean. Phytopathology 28: 270-273. Ap 1938.

Nagel, C. M. The longevity of Cercospora beticola in soil. Phytopathology 28: 342-350. My 1938.

Newhall, A. G. The spread of onion mildew by wind-borne conidia of *Peronospora destructor*. Phytopathology 28: 257-269. f. I-4. Ap 1938.

Ottley, A. M. Occurrence of Centipeda minima in Wellesley, Massachusetts. Rhodora 40: 219, 220. My 1938.

Overholts, L. O. Mycological notes for 1934-35. Mycologia 30: 260-279. f. 1. My-Je 1938.

Pennell, F. W. "Commelina communis" in the eastern United States. Bartonia 19: 19-22. 8 Mr 1938.

Pennell, F. W. More unpublished works of Schweinitz. Bartonia 19: 49. 8 Mr 1938.

- Pennell, F. W. Travels and scientific collections of Thomas Nuttall. Bartonia 18: 1-52. pl. 1-5. 1936.
- Petersen, G. A. Perithecial material of Erysiphe and Microsphaera on Trifolium. Mycologia 30: 299-301. f. 1-4. My-1e 1938.
- Peterson, P. D. & McKinney, H. H. The influence of four mosaic diseases on the plastid pigments and chlorophyllase in tobacco leaves. Phytopathology 28: 329-342. My 1938.
- Petrad, F. Ein neuer Cirsium-bastard aus Nordamerika (C. Wilhelmii). Repert. Spec. Nov. 43: 285-287. 15 Ap 1938.
- Plakidas, A. G. The mode of action of Bordeaux on Mycosphaerella fragariae. Phytopathology 28: 307-329. f. 1, 2. My 1938.
- Pomerleau, R. Recherches sur le *Gnomonia ulmea* (Schw.)
 Thüm. Nat. Canadien 64: 261–289. N 1937; 65: 23–41. pl.
 23–30. Ja 1938; 57–70. F 1938; 89–96. pl. 4–6. Mr 1938;
 125–137. Ap 1938; 167–188. pl. 12–14. 20–22. My 1938.
- Popham, R. A. A contribution to the life history of Galinsoga ciliata. Bot. Gaz. 99: 543-555. f. 1-30. Mr 1938.
- Porsild, A. E. Silene menziesii and allies in western Canada. Rhodora 40: 212-215. My 1938.
- Porterfield, W. H. Trapa bicornis, a water-chestnut known to the Chinese as Ling Ko. Jour. N. Y. Bot. Gard. 39: 134-138. illust. Je 1938.
- Pratt. W. F. & Litchfield, E. W. Western extension of range of *Pinus Banksiana* in New York. Rhodora 40: 241, 242. Je 1938.
- Purer, E. A. Plants of Silver Strand Beach State Park, San Diego County, California. 1–98. frontisp. 1936.
- Quinn, V. Leaves, their place in life and legend i-xi. 3-211. illust. Frederick A. Stokes Co., New York. 1937.
- Rao Panduranga, V. Effect of artificial wind on growth and transpiration in the Italian millet, Setaria italica. Bull. Torrey Club 65: 229–232. f. 1. Ap 1938.
- Raup, H. M. Botanical studies in the Black Rock Forest. Black Rock Forest Bull. 7: iii-v. 1-161. pl. 1-11+f. 1-9. map. Cornwall-on-the-Hudson, New York. 1938.
- Robbins, W. J. Thiamin and growth of species of *Phytophthora*. Bull. Torrey Club 65: 267-276. f. 1, 2. My 1938.
- Roberts, R. H. The effects of temperature and other factors upon the photoperiodic responses of some of the higher plants. Jour. Agr. Res. 56: 633-677. f. 1-46. My 1938.
- Roig, J. T. El Cedro. Santiago de las Vegas Est. Exp. Agron. Circ. 79: 1-31. f. 1-7. My 1935.

- Rossbach, G. B. Northeastward extensions in the Maine flora II. Rhodora 40: 245-247. Je 1938.
- Ryker, T. C. & Gooch, F. S. Rhizoctonia sheath spot of rice. Phytopathology 28: 233-246. f. 1-6. Ap 1938.
- Sears, P. B. This is our world. i-xi. 3-292. illust. Univ. Oklahoma Press. 1937.
- Schmitt, F. O. & Johnson, G. T. Optical and chemical studies on the granules in microspores of *Tradescantia*. Ann. Missouri Bot. Gard. 25: 455-466. pl. 31. Ap 1938.
- Schneider, C. L. The interdependence of auxin and sugar for growth. Am. Jour. Bot. 25: 250-270. f. 1-8. Ap 1938.
- Schneider, C. L. & Went, F. W. A photokymograph for the analysis of the *Avena* test. Bot. Gaz. 99: 470-496. f. 1-14. Mr 1938.
- Schubert, B. G. Vernonia fasciculata, var. corymbosa. Rhodora 40: 220. My 1938.
- Schulz, A. G. Los Asclepiadaceas del Territorio de Chaco (Argentina). Lilloa Rev. Bot. 1: 347-391. pl. 1-5. 1937.
- Schweinfurth, C. Notes on American orchids. Harvard Univ. Bot. Mus. Leafl. 6: 1-12. Ap 1938.
- Sealy, J. R. Myrtus lechleriana. Curt. Bot. Mag. 161: pl. 9523.

 8 Ap 1938.
- A plant from Chile and Argentina.

 Seastone, C. V. The measurement of surface films formed by hemocyanin, tobacco mosaic virus, vaccinia, and Bacterium gallinarum. Jour. Gen. Physiol. 21: 621-629. f. 1-3. 20 My
- Shamel, A. D. The patriarch of trees. Nat. Hort. Mag. 17: 137-142. illust. Ap 1938.
- Sharples, A. W. Alaska wild flowers. i-vii. 1-156. illust. Stanford Univ. Press, California. 1938.
- Shirley, H. L. & Meuli, L. J. Influence of foliage sprays on drought resistance of conifers. Plant Physiol. 13: 399-406.

 f. 1. Ap 1938.
- Shive, J. W. Growing plants without soil. Flower Grower 25: 123-125, 155. illust. Mr 1938.
- Shrock, R. R. Fossil algae from the Salem limestone of Indiana. Science II. 87: 438, 439. 13 My 1938.
- Silveira, F. Mangrove. Rodriguesia 3: 131–154. f. 1–8. S–D
- Silveira Grillo, H. V. Estudo da "murcha" do algodveiro da causada pelo Fusarium vasinfectum Atk. no estado da Parahyba. Rodriguesia 2: 321–327. f. 1–8. D–Mr 1936.

- Singh, B. N. & Rao, A. N. K. A photoelectric photometer for chemical analysis. Plant Physiol. 13: 419-425. f. 1-3. Ap 1938.
- Siple, P. A. The second Byrd Antarctic expedition—botany. I. Ecology and geographical distribution. Ann. Missouri Bot. Gard. 25: 467-514. pl. 32-37. Ap 1938.
- Sisson, W. A. The existence of mercerized cellulose and its orientation in *Halicystis* as indicated by x-ray diffraction analysis. Science II. 87: 350. 15 Ap 1938.
- Skinner, C. E. The "Tyrosinase reaction" of the Actinomycetes. Jour. Bact. 35: 415-424. Ap 1938.
- Skinner, S. A. Effects of freezes in southern California on shade and ornamental trees. Science II. 87: 279, 280. 25 Mr 1938.
- Skottsberg, C. Acaena oligomera. Nov. Spec. Lilloa Rev. Bot. 1:393-396. f. 1. 1937.
- Skottsberg, C. Die flora der Desventurados inseln (San Felix und San Ambrosio) Gotëborgs Kungl. Vet. Handl. 5 & 6: 1-87. f. 1-46. 10 My 1937.
- Skottsberg, C. Further notes on *Vaccinium* of Hawaii. Medded. Gotëborgs Bot. Trad. 12: 145-151. f. 1-4. 1938.
- Skottsberg, C. Liliaceae of southeastern Polynesia. B. P. Bishop Mus. Occ. Papers 13: 233-244. f. 1, 2. 1 N 1937.
- Sleumer, H. Vermischte Diagnosen. IV. Repert. Spec. Nov. 41: 117-128. 25 N 1936; V. Repert Spec. Nov. 42: 257-267. 27 N 1937.
- Smart, R. F. The reactions of the swarm-cells of Myxomycetes to nutrient materials. Mycologia 30: 254-264. My-Je 1938.
- Smith, A. C. & Wodehouse, R. P. The American species of Myristicaceae. Brittonia 2: 393-527. f. 1-9. 2 My 1938.
- Smith, C. P. Species Lupinorum. 1–16. Ap 1938; 17–32. My 1938.
- Smith, H. V. Notes on fossil plants from Hog Creek in southwestern Idaho. Papers Michigan Acad. Sci. 23: 223-231. pl. 1. 1938.
- Smith, L. B. Sinopsis de las especies Argentinas del genero Buddleja. Lilloa Rev. Bot. 1: 397-413. pl. 1. 1937.
- Solheim, W. G. Mycoflora Saximontanensis exsiccata. Univ. Wyoming Publ. 3: 89-99. 1 S 1937.
- Sprague, T. A. Berberis Chillanensis var. Hirsutipes. Curt. Bot. Mag. 160: pl. 9503. f. 1-8. 24 Ja 1938.
- Stahel, G. Notes on *Cercospora* leaf spot of bananas. Jour. Imp. Coll. Trop. Agr. 14: 257-264. pl. 1-8. S 1937.

- Stancliff, O. Flowers of the higher Sierra. Am. Bot. 44: 52-54. Ap 1938.
- Stanley, O. B. Indicator significance of lesser vegetation in the Yale Forest near Keene, New Hampshire. Ecology 19: 188-207. f. 1-4. Ap 1938.
- Stebbins, G. L. The scadent species of *Prenanthes* and *Lactuca* in Africa. Bull. Jard. Bot. Bruxelles 14: 333-352. pl. 6-8. D. 1937.
- Steere, W. C. Bryophyta of Arctic America. I. Species from Little Diomede Island, Bering Strait, Alaska. Am. Midl. Nat. 19: 436-439. Mr 1938.
- Stehle, H. & McQuentin, L. Flora de la Guadeloupe et dépendances. II. Catalogue des phanérogames et fougéres avec contribution à la flore de la Martinique. i-xii. 1-236. illust. Basse-Terre. 1937.

 Includes description of Lindernia microcalyx spec. nov.
- Steiner, M. Beobachtungen über Schädigungen der Vegetations-Organe nordamerikanischer Strand-pflanzen durch unmittelbare Salzewassereinwirkung. Biol. Generalis 2: 284-303. pl. 4, 5. f, 1, 2. 1935.
- Stokes, S. G. Further studies in *Eriogonum*. II. Leafl. West. Bot. 2: 52, 53. 20 N 1937; III. 72. Ja 1938.
- Stout, A. B. The flowering behavior of Norway maples. Jour. N. Y. Bot. Gard. 39: 130-134. illust. Je 1938.
- Strain, H. H. Formation of carotenoids and chlorophylls in etiolated barley seedlings exposed to red light. Plant Physiol. 13: 413-418. f. 1. Ap 1938.
- Street, R. B. Phymatotrichum (cotton or Texas) root rot in Arizona. Univ. Arizona Tech. Bull. 71: 296-410. pl. 1-32. f. 1. 15 S 1937.
- Svenson, H. K. Pteridophyta of the Galapagos and Cocos Islands. Bull. Torrey Club 65: 303-333. pl. 8-10. My 1938.
- Tapke, V. F. Influence of environment, after seedling emergence, on covered smut barley. Phytopathology 28: 370, 371. My 1938.
- Teller, G. L. Plant diastase in evidence as to the formation and structure of starch granules. Plant Physiol. 13: 227-240. f. 1-7. Ap 1938.
- Thatcher, R. W. The chemistry of plant life. i-xvi. 1-268. McGraw-Hill Book Co., New York. 1921.
- Thimann, K. V. & Schneider, C. L. The role of salts, hydrogenion concentration and agar in the response of the *Avena* coleoptile to auxins. Am. Jour. Bot. 25: 270-280. f. 1-8. Ap 1938.

- Thorne, D. W. & Brown, P. E. The growth and respiration of some soil bacteria in juices of leguminous and non-leguminous plants. Jour. Bact. 34: 567-579. f. 1. D 1937.
- Thornton, N. C. Extraction and determination of vitamin C in plant tissue. Contr. Boyce Thompson Inst. 9: 273-282. Ap-Je 1938.
- Tompkins, C. M. & Thomas, H. R. A mosaic disease of Chinese cabbage. Jour. Agr. Res. 56: 541-551. f. 1-5. 1 Ap 1938.
- Torrey, R. H. Collecting Cladoniae on Martha's Vineyard and Nantucket Islands. Torreya 38: 67-71. My-Je 1938.
- Torrey, R. H. Lichens, the hardy pioneers of plant life. Nat. Hist. 41: 266-270. illust. Ap 1938.
- **Tresidder, M. C.** The trees of Yosemite. ix-xiv. 1-133. *illust*. Stanford Univ. Press. California. 1932.
- Troncoso, N. S. Las Verbenaceas cultivadas en Buenos Aires. Darwiniana 3: 49-59. 1937.
- True, R. H. Lepidium perfoliatum in the Philadelphia area. Bartonia 19:48. 8 Mr 1938.
- Truman, H. V. Further note on Verbena stricta forma albiflora. Rhodora 40: 244, 245. Je 1938.
- **Tudey, H. B.** Growth patterns of plants developed from immature embryos in artificial culture. Bot. Gaz. **99:** 630-665. f. 1-19. Mr 1938.
- Ubisch, G. von. A alteração da morphologia de flores pelos Ustilaginales. Rodriguesia 2: 323-327. 1936.
- Uittien, H. Pavonia Julianae et Paullinia Bernhardi, novae species Surinamenses. Meded. Bot. Ryks Univ. 39: 770-774. f. 1, 2. D 1936.
- Ulke, T. A new genus and species of fossil algae. Torreya 38: 57-62. f. 1-5. My-Je 1938. Globulinea giganteus.
- Umbreit, W. W. & Burris, R. H. Composition of soybean nodules and root nodule bacteria. Soil Sci. 45: 111-126. F
- Uphof, J. C. Pinckneya pubens Rich. Mitteil Deutsch. Dendrol. Gesell. 49: 1-4, f. 1, 2. 1937.
- Urban, O. Plantas Endemicas de Chile. i-vii. 1-291. illust. 1934.
- Valleau, W. D. & Johnson, E. M. Tobacco mosaic sources of infection and control. Kentucky Agr. Exp. Sta. Bull. 376: 221-262. D 1937.
- Vallega, J. Observaciones sobre la resistencia a la roya de algunos linos ensoyados en el Instituto fitotecnico de Davalloi. Rev. Argentina Agron. 5: 25-56. Mr 1938.

- Varrelman, F. A. Anent parthenocarpic apples. Science II. 87: 414. 6 My 1938.
- Vestal, P. A. The significance of comparative anatomy in establishing the relationship of the Hypericaceae to the Guttiferae and their allies. Philippine Jour. Sci. 64: 199-256. pl. 1-9. N 1937.
- Voorhees, R. K. Eye-spot disease of Napier grass. Phytopathology 28: 438-443. f. 1-3. Je 1938.
- Walker, J. C. Diseases of cabbage and related plants. U. S. Dept. Agr. Farm Bull. 1439: 1-35. f. 1-13. Ja 1938. Revised Bulletin.
- Walker, R. I. Macrosporogenesis and embryo development in *Ulmus fulva*. Bot. Gaz. 99: 592-598. f. 1-28. Mr 1938.
- Walder, R. I. The effect of colchicine on microspore mother cells and microspores of *Tradescantia paludosa*. Am. Jour. Bot. 25: 280-285. f. 1-14. Ap 1938.
- Walther, E. Notes on the genus *Echeveria*. Jour. Cactus & Succ. Soc. Am. 9: 147, 148. *illust*. Mr 1938.
- Watkins, J. V. Experiments with hormodin on semi-tropical plants. Florists Exch. 90:12, 13. f. 1, 2. 5 Mr 1938.
- Wehmeyer, L. E. Cultural life histories of *Melanconis* and *Pseudovalsa*. III. The genus *Prosthecium* Fres. emend Petrak. Papers Michigan Acad. Sci. 23: 233-242. pl. 1-3. 1938.
- Weston, W. H. Heterothallism in Sapromyces Reinschii. Mycologia 30: 245-253. f. 1. My-Je 1938.
- Whelden, R. M. Changes observed in cultures of Aspergillus niger bombarded as spores with low voltage cathode rays. Mycologia 30: 265-268. f. 1. My-Je 1938.
- Wherry, E. T. Miscellaneous eastern Polemoniaceae. Bartonia 18: 52-59. pl. 6+f. 1, 2. 1936.
- Wherry, E. T. Polemonium and Polemoniella in the eastern States. Bartonia 17: 5-12. pl. 2+f. 1, 2. 2 Ap 1936.
- Wherry, E. T. The ranges of our eastern Parnassias and Sedums. Bartonia 17: 17-20. 2 Ap 1936.
- White, P. R. Accessory salts in the nutrition of excised tomato roots. Plant Physiol. 13: 391-398. f. 1-4. Ap 1938.
- Whitney, L. D. A new species of *Trisetum* and a new variety of *Panicum* imbricatum from Hawaiian Islands. B. P. Bishop Mus. Occ. Papers 13: 171–173. f. 1, 2. 5 Au 1937.
- Whitfield, C. J. & Anderson, H. L. Secondary succession of the desert plains grassland. Ecology 19: 171–180. f. 1–4. Ap 1938.

- Whiting, A. G. Development and anatomy of primary structures in the seedling of *Cucurbita maxima*. Bot. Gaz. 99: 497-528. f. 1-6. Mr 1938.
- Wilder, L. B. The garden in color. 1-327. pl. 1-319. Macmillan Book Co., New York. 1937.
- Williams, J. W. Effects of surface tension and osmotic pressure on the gross morphology of certain pathogenic fungi. Jour. Bact. 35: 409-414. Ap 1938.
- Williams, L. O. A note concerning two South American orchids. Harvard Univ. Bot. Mus. Leafl. 5: 143. 5 Mr 1938.
- Williams, L. O. Orchid studies. IV. The orchids of the Fiji Islands. Harvard Univ. Bot. Mus. Leafl. 5: 105-144. Mr 1938.
- Wilson, W. C. Collecting western alpines by air. Nat. Hort. Mag. 17: 89-116. illust. Ap 1938.
- Winkler, A. J. & Williams, W. O. Carbohydrate metabolism of *Vitis vinifera* hemicellulose. Plant Physiol. 13: 381–390. Ap 1938.
- Winston, J. R. Algal fruit spot of orange. Phytopathology 28: 283-286. f. 1, 2. Ap 1938.
- Wood, A. H. Bulbs for your garden. i-xxv. 3-210. illust. Riverside Press, Cambridge, Mass. 1936.
- Wood, O. M. Seedling reproduction of oak in southern New Jersey. Ecology 19: 276-293. f. 1-4. Ap 1938.
- Woodcock, E. F. Vegetative anatomy of the tomato (Lycoper-sicium esculentum Mill) III. Diploid and haploid plants. Papers Michigan Acad. Sci. 23: 243-245. pl. 1+f. 1. 1938.
- Young, E. L. Labyrinthula on Pacific Coast eel-grass. Canadian Jour. Res. 16: 115-117. Mr 1938.
- Yuncker, T. G. A contribution to the flora of Honduras. Field Mus. Nat. Hist. Publ. Bot. 17: 287-407. pl. 1-18. Ja 1938.
- Zimmerman, P. W. & Hitchcock, A. E. Tropic responses of leafy plants induced by application of growth substances. Contr. Boyce Thompson Inst. 9: 299–328. f. 1–7. My–Je 1938.

INDEX TO VOLUME 65

New names and the final members of new combinations are in bold face type.

Abies 534, 537, 552, 553; concolor 556; venusta 546

Abortiporus distorus 655; subabortivus 655, 661

Absidia 461

Acacia longifolia 556; suaveolens 556

Acaena o igomera 670

Acer 526, 561; Bendirei 561, 562; Bolanderi 558, 562; Buergerianum 558, 562; glabrum 561; grandidentata 562; japonicium 584; macrophyllum 561; Negundo 561, 562; negundoides 562; Osmonti 561; rubrum 169, 171, 172; saccharum 562; tripartum 562

Aceretum rubri 494

Achlya apiculata 623; bisexualis 505; flagellata 593

Acicalyptus 204

Acmena 425

Acocanthera spectabilis 136

Aconitum noveboracense 257

Acoridium 581

Acorus Calamus 663

Acrostichum 307; apodum 331; aureo-nitens 328; aureum 305-307, 373; crinitum 332; Fendleri 375; Gillianum 328; muscosum 318; viscosum 318; viscosum glabriusculum 318 Additional Miocene plants from Grand Coulee,

Washington 89

Adenium coetenium 137, 145, 160

Adiantum 307; aethiopicum 307; Alarconianum 304, 307; concinnum 305, 307, 308; cuneatum 307; diaphanum 307, 308; Henslovianum 306-308; incisum 307; Kaulfussii 308; macrophyllum 305, 306, 308; parvulum 307, 308; patens 304, 308; petiolatum 305, 308; prionophyllum 308; tetraphyllum 304, 308; villosum 305, 306, 308

Aegiphila 590

Agaricus 497; abruptibulbus 172

Agave 76

Agropyron 262; Smithii 497

Aidia cochinchinensis 614

Ailanthus altissima 126, 528

Albidi 233-235

Aleurodiscus acerinus 170

Alga: Oedocladium Lewisii, A new green 23 Algae in a Minnesota pond, The taxonomy of a community of blue-green 377

Algae, Notes on Maryland 293

Allamanda cathartica 136, 145, 156, 158

Allium cepa 342, 439, 443, 615; stellatum 72

Allomyces 495

Allotropa 335

Alnus 521, 526

Aloe aethiopica 522; arborescens 522; ciliaris 522; Cooperi 522; haemanthifolia 522; plicatilis 522; rubrolutea 522; speciosa 522; variegata 522; viscosa 522

Alsophila 314

Alternaria citri 207

Amarantus 208

Amaryllis longifolia 182

Amblyarrhena 580

Ambrosia 262; elatior 262

Amelanchier florida tomentosa 208

American Botanical Literature, Index to 70, 123, 198, 256, 334, 421, 493, 581

American Celastraceae 1. New species of Microtropis, Wimmeria and Zinowiewia, Studies in the 463

American melastomes, including nine new species, Notes on 571

American species of Dryopteris, subgenus Meniscium, The 347

Amorphophallus titanum 125, 127, 209

Ampelocera 209; glabra 341

Amphianthus 340

Amphichloris 297

Amsonia ciliata 136, 144, 160; rigida 432

Anabaena 393; constricta 393; flos-aquae 288, 290; planctonica 393; spiroides 393

Anagallis arvensis 256

Ananthocorus 309; angustifolius 304, 309

Anaphilis margaritaceae 664

Ancylistes 257

Anisostemones 571

Ankyropteris grayi 605; henricksi 605

Anogramma 308; chaerophylla 308; leptophylla 306, 308

Aphanizomenon flos-aquae 288

Aphanomyrtus 264

Apocynaceous flowers, The vascular anatomy

and comparative morphology of 135

Apocynum 135, 138, 149, 150, 152, 160, 162; androsaemifolium 137, 145, 149, 161; cannabinum 137, 142, 145, 156, 160, 161

Arabis lyrata 256

Arachnoxylon 601, 604, 605, 606; kopfi 602, 604-606

Arachnula 443

Aragoa 500

Aralia 201

Araucaria 553; angustifolia 516, 520

Arcella vulgaris 443

Arceuthobium 128

Arctostaphylos 265; Uva-ursi 260

Argyrodendron 200

Argyroderma 262

Ariocarpus 263

Aristida stricta 491, 492

Artemisia 404, 408-410

Arthrospira 387–390, 395; Jenneri 388; platensis 290

Arthrostemma 576, 577; alatum 576, 577; apodocarpum 576; campanulare 576, 577; fragile 576; hirtellum 577; macrodesmum 577; parvifolium 576, 577

Asclepias erosa 582

Asimina 412 520, 526

Asparagus officinalis 526

Aspergillus alliaceus 593; niger 276, 460, 502,

Aspidium articulatum 332; biserratum 332; coriaceum 327; martinicense 328; semicordatum 313

Aspidosperma quebrachoblanco 203

Asplenium 330, 348; anisophyllum latifolium 311; anisophyllum sanguinolentum 311; auritum 305, 306, 309; auritum macilentum 309; carolinum 304-306, 310; cicutarium 310; cristatum 305, 310, 330; dubium 330; Fernandezianum 311; formosum 304-306, 310; furcatum 311; laetum 304, 310; lunulatum 309; Macraei 310, 330; marinum auriculatum 309; myriophyllum 305, 310; nigrescens 311; nubilum 311; poloense 304, 310; praemorsum 306, 311; pulchellum 311; pulcherrima 311; pumilum 305, 311; rhizophyllum 310, 330; rigidum 309; rutaceum 304, 311; sanguinolentum 311; sarcodes 311; Serra 305, 312; serratum 304, 312; sorbifolium 347, 358; subulatum 303, 310; sulcatum 309

Aster 300, 639

Asteroclaena laxa 605

Asteropteris 602, 605; kopfi 602; novaboracensis 604-606

Asterostroma cervicolor 170

Asteroxylon 604, 606; mackiei 606

Astragalus 75, 424; Bergii 128; distortus 256 Aurantiporus croceus 649

Aurator 233-235

Aurator, Studies in Penstemon VI. The section

Auricularia Auricula-Judae 170; rosea 170 Austroclepsis osborni 605

Aveledoa 72

Avena 11, 123, 126, 335, 422, 432, 664, 669, 671; fatua 11, 21; sativa 443, 555

AVERY, JR., GEORGE S. and CARL D. LARUE, The development of the embryo of Zizania aquatica in the seed and in artificial culture 11

Azolla 329, 526; caroliniana 329, 437, 518; filiculoides 329

Baccharis halimifolia 489

Bacillus mycoides 592

Bacterium angulatum 262; gallinarum 669; tabacum 262; tumefaciens 202

Bambusa ventricosa 589

Bangia atropurpurea 291

Beaumontia grandiflora 137, 146

Begonia incana 265

Berberis amplectans 594; Chillanensis Hirsutipes 670

BERRY, EDWARD W., Additional Miocene plants from Grand Coulee, Washington 89 Betula 62, 64, 520; Bendirei 558, 562; fontinalis 560; lacustris 560; occidentalis 558, 560

Bidens 208, 526

Blastospora 625, 626; Butleri 625, 626, 628; smilacis 626

Blechnum blechnoides 312; occidentale 305, 312; occidentale caudatum 312; unilaterale 305, 306, 312

Blue-green algae in a Minnesota pond, The taxonomy of a community of 377

Bolbitis 375; macrophylla 374-375; subcrenata 375

BOLD, HAROLD C., Notes on Maryland algae 293 Boletus chrysenteron 168, 174

Bolinia tubulina 169

Borzicactus aurivillus 430

Botanical Literature, Index to American 70, 123, 198, 256, 334, 421, 493, 581, 675

Botrydium 23

Botrytis 497

Bouteloua curtipendula 493

BRANDWEIN, PAUL F., The emergence of smutinoculated oat seedlings through sand and loam soil 477

Brasenia 281, 282; peltata 277, 283 Brasenia, The winter buds of 277

Brassica 425

Brodiaea 129

Browallia 665

Bryoxiphium norvegicum 502

BUELL, HELEN FOOT, The taxonomy of a community of blue-green algae in a Minnesota pond 377

Bulliardella 588

Bumilleria 450

Buxus sempervirens 665

Cactaceae of southern Utah, The 397 Cacti from Guatemala, Mexico and Texas,

New species of 565 Caesalpinia 125

Calamus 512

Calidion 627

Callicarpa 590

Callirhoë 589

Calocera cornea 170

Calothrix Contarenii 287; parietina 288, 289; pilosa 287

Calycanthus 663

Calyptrogyne-Calyptronoma 581

CAMP, W. H., Studies in Ericales III. The genus Leiophyllum 99

CAMPBELL, W. A., The cultural characteristics of the species of Fomes 31

Camplyoneuron latum 332; Phyllitidis 325

Canavalia ensiformis 423

Canna 1, 4, 6, 7

Cannabis sativa 508, 510

Cantharellus cibarius 172

Capsella 511

Carex 73, 133, 208, 262, 502

Carissa Carandas 136, 144; grandiflora 136, 144

Carpinus 594

Carteria 297; crucifera 296, 300, 301; ellipsoidalis 296, 300, 301; globosa 297

Carya Buckleyi arkansana 555

Castalia tetragona 341

Castanea dentata 124, 524; orientalis 89

Castanopsis consimilis 89, 91, 92

Castilla 665

Castilleja 500

Castilloa 665

Catalpa speciosa 526

Cathestecum 593

Catinula turgida 338

Celtis 520

Cenangella Ravenelli 169

Centaurea macrocephala 256

Centipeda minima 667

Centradenia 571; Bernoulli 571; chiapensis 571; floribunda 571; grandifolia 571; Maxoniana 571; salicifolia 571

Centradeniopsis 571

Centranthera 264

Centropyxis 443

Centrosema 583

Cephalanthus occidentalis 175, 179

Ceracea corticioides 170

Ceratophyllum 283

Ceratostomella Ulmi 134

Cerbera 159, 160; Tanghin 136, 145, 155, 156, 159, 160

Cercis 507, 520, 526

Cercospora 73, 76, 199, 258, 592, 663, 670; beticola 667; musae 73; oryzae 593; rhoina 169

Cercosporella 73; herpotrichoides 73

Ceropteris monosticha 322; tartarea 324

Cervantesia 208

Cetraria islandica 343

Chaconia 625-627; alutacea 625, 627; Butleri 628; texensis 626

Chaconia, Studies in the Uredinales, the genus 625

Chaetolepis 572; alpina 572; brevistrigillosa 572; cubensis 572; Grisebachii 572; saturaeoides 572

Chaetomium 344, 429

Chamaesyce 521, 526; preslii 522

Chaptalia Hintoni 125; nutans 125

Chara 440, 443; coronata 439, 443, 615

Cheilanthes 312; affinis 322; Borsigiana 322; candida 322; cretacea 322; heterotricha 312; lutea 320; microphylla 305, 312; monosticha 322; myriophylla 312

Chelone abida 237; cristata 250; erianthera 250

Chimaphila 666

Chlamydobotrys 299; gracilis 299; stellata 293, 299-301

Chlamydomonas breviciliata 298; metastigma 297, 300, 301; Reinhardi 301; schizochlora 297, 300, 301

Chlorella vulgaris 597

Chloridium musae 73

Chondropodium 78

Chroococcus 387; turgidus 387, 394, 450

CHRYSLER, M. A., The winter buds of Brasenia 277

Chrysocelis 627

Chrysodium vulgare 373

[VOL. 65

Chytridium 623; aggregatum 617, 620; gibbosum 617; Schenkii 617

Cimicifuga 343

Cirsium 668; Wilhelmii 668

Citrus 199, 425; sinensis 124

Cladonia 435; Boryi 435

Cladophora 285, 440; glomerata 439, 440, 443, 616

Claviceps Paspali 589

Cleistocalyx 204

Clematis Addisonii 78

Clistoyucca 404

Chrocybe decora 172

Clonothrix fusca 339

CLOVER, ELZADA U., New species of cacti from Guatemala, Mexico and Texas 565; The cactaceae of southern Utah 397

Coccopedia 383

Cochemiea 430; setispina 430

Cocos Islands, Pteridophyta of the Galapagos and 303

Coelomoron 379, 394; regularis 378, 379, 394

Coelosphaerium 379; Nägelianum 380

Coleosporium campanulae 589; Solidaginis 170, 589; Vernoniae 170

Coleus 641; Blumei Renhaltianus 663

Colletia 208

Colocasia esculenta 498

Columnea 428

Comatricha 201

Combretum fruticosum 225; Loeflingii 228

Commelina communis 667

Conferva canalicularis 292; ebena 291; ericetorum 291

Conidiobolus 202

Coniophora olivascens 170

Convolvulus 641

Cooperia 79, 80, 84–87, 424; albicans 80, 83, 84; chlorosolen 80–82; Drummondiana 80; Drummondiana chlorosolen 81; Drummondii 79–83, 85–87; Drummondii chlorosolen 80–82; mexicana 85; miradorensis 86; pedunculata 79, 80, 84, 85; Traubii 80, 82

Cooperia, The genus 79

Copernicia 581

Cordyceps 264

Cordyline terminalis 526

Corema Conradii 437

Coreopsis saxicola 256

Coriolopsis Tisdaleana 656, 661.

Coriolus abietinus 658; depauperatus 658; limitatus 658; membranaceus taxodii 657;

subabietinus 658, 661; sublimitatus 658, 661; tenuispinifer 658, 661

Cornus 97, 132; acuminata 97; **Becki** 89, 95, 97; canadensis 97; florida 97, 500; Nuttallii 97

Corticium chrysocreas 170; coronilla 257; galactinum 170; incrustans 204; lactescens 170; lividum 170; portentosum 170; salmonicolor 206; stramineum 170

Corylus 594

Coryneum microstictum 262

Coryphantha 406, 410; aggregata 410; arizonica 410; chlorantha 410; deserti 410, 412; Echinus 410; Marstonii 404, 412

Cosmarium 591

Costus 521; speciosus 521, 526

Cotyledon sinus-Alexandri 591

Covillea 404; tridentata 406, 408, 410

Crassula multicava 340

Crenothrix polyspora 339

Crepis 209

Cristati 234, 235

Cronartium occidentale 129; ribicola 129, 204, 496, 499, 588

Crotalaria juncea 72

Croton capitatum 170

Crusonia wrightiana 78

Cryptanthus Glaziovii 72

Ctenoderma 627

Cucurbita maxima 674; Pepo 259

Cufodontia 146; Stegomeris 136

Cultural characteristics of the species of Fomes, The 31

Cupulifera 613

Cuscuta 76, 631, 632, 637, 643-645; arvensis calycina 631; campestris 631, 632, 636, 639, 643, 644; Cephalanthi 632, 633, 635, 636, 642-644; compacta 632, 636, 649, 641, 643, 644; curta 642; epilinum 631; epithymum 631, 645; epithymum vulgaris 631; europaea 631; glomerata 632, 633, 636, 639, 642-645; Gronovii 632, 633, 635, 636, 638, 642-645; indecora 641; indecora neuropetala 632, 636, 641, 643, 644; monogyna 631, 643-645; pentagona 632, 633, 636, 639, 640, 643, 644; reflexa 635, 645; rostrata 642, 643

Cuscuta, The cytology of 631

Cyanothrix primaria 285, 286; Willei 285, 286

Cyathea purpurea 318

Cyathodium 494; barodae 199

Cycas 518; revoluta 518

Cycladenia 160; humilis 137, 145, 160, 162

Cyciamen 643 Cyclopeltis 313; semicordata 304, 313 Cylindrocarpon Ehrenbergi 126 Cylindrocystis 450 Cylindropuntia 400 Cynara Scolymus 525 Cyperus 340, 510; alternifolius 521, 522, 526; pilosus 341 Cytology of Cuscuta, The 631

Dactylella bembicodes 259

Dactylina artica 134 Daedalea ambigua 174, 647; confragosa 174; elegans 174; farinacea 174; juniperina 651; quercina 647; unicolor 174; Westii 649 Daldinia concentrica 169 Danaea 330, 550; nodosa 330 Darluca filum 169 Dasyscypha Willkommii 338 Datura 432; stramonium 198, 207, 257 Deamia diabolica 568, 570; Testudine 570 Debaryomyces 499

Delphinium albescens 28; azureum 27, 28; azureum Nortonianum 28; azureum vimineum 29; azureum virescens 28; camporum 29; carolinianum 27-29, 340; carolinianum crispum 28; carolinianum Nortonianum 28; carolinianum Penhardii 28; macroseratilis 29; Nortonianum 28; Penardi 28, 29; vimineum 29; virescens 28; virescens camporum 28, 29; virescens Penardi 28; virescens vimineus 28, 29; Wootoni 29

Delphinium carolinianum and its allies 27 Dendrium 99; Hugeri 101 Dendrochium compressum 169 Dendrostilbella 169

Dennstaedtia 313, 330; glauca 588; globulifera 313, 330

Desmarestia 504

Development of the embryo of Zizania aquatica in the seed and in artificial culture

Dicentra cucullaria 258

Dicranopteris 313, 330; linearis 313; pectinata 330

Dictyocha fibula 128

Dictyosteliam discoideum 206

Difflugia urceolata 443

Diodia 128

Dioon edule 518, 520

Diospyros 97, 98, 607-609, 613; Andersonae 89, 91, 97; Christophersenii 613; cupulosa 613; ellipticifolia 610, 612; ellipticifolia elliptica 611, 612; ellipticifolia iridea 612; ferrea 609, 612; ferrea angustifolia 611; ferrea Gillespiei 610, 611; ferrea littorea 610; ferrea nandarivatensis 610; ferrea sandwicensis 610; ferrea savaiiensis 611: ferrea subimpressa 611; globosa 612; lateriflora 612, 613; princetoniana 98; rufa 613; samoensis 613; sericocarpa 613; virginiana 98; virginica 564

679

Diplazium 313; cristatum 374; obtusum 313; subobtusum 313, 322; undulosum 358

Diplocarpa 71

Diplophlyctis 440, 451, 621

Diplusodon 71

Dipteronia insignis 558, 561; sinensis 564

Dipteryx odorata 426

Distyla 443

Dodecatheon 127

Doryopteris 313; concolor 313, 314; pedata 305, 306, 313, 314

Dothichloe atramentosa 169

Dothiorella 134

Douglasia 335

Downingia 130

Draparnaldia 615

Drosophila melanogaster 443

DROUET, FRANCIS, Notes on Myxophyceae I-IV 285

Drymaria 498

Dryopteris 203, 304, 314, 347, 348, 360, 370, 375; affinis 364; ampla 314, 315; anceps 375; Andreana 350, 352, 365; Andreana glabra 352; angustifolia 350, 361; arborescens 369; arcana 350, 352, 354; brachyodus 315; Christii 348, 376; chrysodioides 351, 373-375; chrysodioides goyazensis 351, 374; Clintoniana 78; columbiana 314, 315; consobrina 350, 354-356; dentata 315, 316; Desvauxii 349, 351, 369, 370, 372; Desvauxii f. glandulosa 348, 351, 372; dispar 351, 364; ensiformis 350, 359; falcata 360; furcata 314; Ghiesbreghtii 348; gigantea 364, 365; glandulosa brachyodus 304, 315; gongylodes 305, 306, 315; Hostmanni 349, 351, 358, 269, 370; inaequalifolia 317; Jurgensenii 349, 350, 359, 360; Lechleri 366; Liebmanni 348; lingulata 350-352, 359; longifolia 369; macrophylla 374; membranacea 351, 365, 366, 374; meniscioides 348; mollis 306, 315, 316, 372; nesiotica 350, 362; pachysora 360; parasitica 314, 316; patens 305,

316; permollis 349, 351, 358, 370, 372; pilosula 314, 315; pleiosora 316, 317; Poiteana 305, 317, 348; pseudotetragona 317; reticulata 317, 350, 357, 358, 360, 372, 373; reticulata arborescens 369; reticulata longifolia 369; reticulata serrata 354; reticulata sorbifolia 358; Rolandii 318; rudis 304, 317; Salzmanni 350, 357, 360, 376; serrata 350, 354–357; simplicifrons 350, 354, 364, 365; sorbifolia 372; sorbifolia confertivenosa 360; sorbifolia mollis 372; sorbifolia punctivenulosa 360; Stand-Teyi 351, 368, 369; subincisa 304; tetragona 305, 317; tricholepis 316, 317; turrialbae 350, 357; villosa 316

Dryopteris, subgenus Meniscium, The American species of 347

Dysmorphococcus 298; coccifera 299; variabilis 298, 300, 301

Echeveria 134, 503, 594, 673

Echinocereus 666; coccineus 406; Engelmanni 398, 400, 402, 404, 406; Fendleri 406; Gentryi 565, 566; mojavensis 404, 406; octacanthus 406, 410; papillosus 124; pensilis 427, 430; Reichenbachii 400; Steereae 565, 568; subinermis 565; triglochidiatus 406

Echinodorus tenellus 341

Echinomastus Johnsonii 398, 400, 404, 408

Effect of artificial wind on growth and transpiration in the Italian millet, Setaria italica 229

Eichleriella Leveilliana 170

Eidamella spinosa 127

Elaphoglossum 318, 328, 330; apodum 330, crinitum 332; mucosum 318; petiolatum 305; 306, 318

Eleocharis 429

Elfvingia applanata 647, 648; marmorata 647; tornata 647

Elsinoe 338, 497; australis 421; ledi 665 Elymus virginicus 207

Emergence of smut-inoculated oat seedlings through sand and loam soil, The 477

Endochytrium 440, 451, 621

Endothia parasitica 335

Endothiella gyrosa 169

Entophlyctis 451, 621

Entyloma australe 170

Ephedra 663

Epidendrum coriifolium 74; pansamalae 428 Equisetum 329, 510, 516, 518, 526, 528, 550; arvense 525; bogotense 329; octangulatum 558; palustre 556; pratense 518; scripoides 518, 526

Eragrostis 78, 431; cilianensis 133

Ericales III. The genus Leiophyllum, Studies in 99

Eriogonum 209, 671

Erwinia cytolytica 663

Erysiphe 668; graminis hordei 75, 258; Polygoni 596

Erythrina 588

Erythronium mesochoreum 131

Eschscholtzia californica 124

Espeletia grandiflora 256

Eucalyptus 206

Eucarteria 297

Eucentradenia 571

Euchlaena mexicana 259

Eudorina elegans 293

Eudryopteris 203

Eugaura 106

Eugenia Hookeri 201

Euglena viridis 443

Euglypha 443

Euheeria 573

Eumiconia 579

Eupatoria 431

Euphorbia 259, 336, 430, 494; calonesiaca 494; Caput 583; dentata 499; lacta 524; pseudocactus 586

Eustylis purpurea 72

Exidia alba 170

Fagus 520; americana 524; pacifica 89

Fagus-Acer 128

Fasciola hepatica 443, 444, 615

Ferocactus acanthodes 400, 404, 402, 408; Lecontei 408; Wislizeni 408

Ferreola 609, 612, 613; buxifolia 609; ellipticifolia 611

Ficus 97, 591; nitida 424

Flammula eccentrica 172

Flindersia 261

Florida Polypores, New 647

FOGELBERG, SIDNEY O., The cytology of Cuscuta 631

Fomes 31, 32, 35, 37, 41, 44-46, 48, 52, 53, 61, 65-68, 335; annosus 35, 37, 38, 56, 63, 66; applanatus 31, 35, 37, 38, 40, 44, 56, 62, 69, 174, 665; Calkinsii 35, 38, 40-42, 54-56, 61, 64, 168, 174; conchatus 35, 38, 40, 41, 48, 53, 56, 61, 63, 174; connatus 125; densus 35, 38, 40-42, 46, 55, 56, 61,

64, 174; Everhartii 35, 38, 40, 42, 56, 64; fomentarius 35, 38, 42, 43, 56, 62, 63; fraxineus 31, 35, 38, 40, 43, 44, 56, 58, 62, 69, 174; fraxinophilus 35, 38, 43, 44, 56, 60, 62; fulvus 35, 38, 44, 45, 56, 63, 64, geotropus 35, 38, 45, 52, 56, 63, 169, 174; igniarius 35, 38, 42, 46-48, 54-56, 61, 64, 69, 134; igniarius laevigatus 35, 38, 46, 47, 56, 63, 174; igniarius nigricans 47; igniarius populinus 35, 38, 41, 47, 48, 56, 63; juniperinus 35, 38, 48, 56, 63; lignosus 496; lobatus 35, 38, 44, 48, 49, 56, 63, 174; marmoratus 35, 43, 49, 50, 58, 63, 174; meliae 35, 50, 53, 54, 56, 58, 62, 174; officinalis 35, 50, 53, 58, 62, 69; ohiensis 35, 50, 52, 53, 58, 61, 62; Pini 35, 41, 50, 53, 54, 58, 63; pinicola 31, 35, 50, 53, 54, 56, 58, 63, 69, 424; rimosus 35, 40, 42, 46, 50, 54, 58, 61, 64, 174; robustus 35, 41, 42, 46, 50, 54, 55, 58, 61, 64, 168; robustus tsugina 35, 48, 55, 56, 58, 61, 63; roseus 35, 50, 54, 56, 58, 63, 69; scutellatus 35, 50, 58, 63; subroseus 35, 50, 54, 56, 58, 60, 63, 649; taxodii 661; tenuis 35, 50, 53, 56, 58, 60, 63, 174; torulosus 35, 40, 46, 50, 54, 55, 58, 61, 64, 174 Fomes, The cultural characteristics of the species of 31 Fomitiporia punctatiformis 659, 661 Forsteria 609, 612, 613 Forsteronia viridescens 137, 144, 158

A

Forsteria 609, 612, 613
Forsteronia viridescens 137, 144, 158
FOSBERG, F. R., Notes on plants of the Pacific Islands. 1. 607
FOSTER, ADRIANCE S., Structure and growth of the shoot apex in Ginkgo biloba 531

Fourcroya 518
Franklinia alatamaha 665
Frankliniella insularis 592
Franseria 595
Fraxinus 502, 581; americana 426
Fremyella vitiensis 287
Froelichia floridana 664
Fucus 258, 264, 431
Fungi from the lower Mississippi Valley, Notes on 167

Funtumia elastica 137, 144, 148, 159, 166
Fusarium 257, 259, 505; coeruleum 665; culmorum 337; lycopersici 427; vasinfectum 75, 669

Gaillardia 421 Galapagos and Cocos Islands, Pteridophyta of the 303

Galinsoga ciliata 668
Galium circaezans 525; concinnum 525; triflorum 525

Ganoderma 647 Garnotia 595

Gaura 105, 225, 425, 667; angustifolia 106, 107, 116, 117, 213; angustifolia Eatonii 117, 118; angustifolia simulans 117, 118; angustifolia strigosa 117, 118; angustifolia typica 117, 226; australis 110; biennis 105, 106, 111, 112, 114; biennis Pitcheri 112, 113, 119; biennis typica 112, 113, 226; brachycarpa 105, 106, 211, 213, 226; bracteata 222; brassicacea 121; canescens 107; chinensis 225; cinerea 214; coccinea 107, 220, 221; coccinea arizonica 221, 225; coccinea epilobioides 221, 222; coccinea glabra 221, 223-225; coccinea integerrima 221; coccinea parvifolia 221, 223, 224; coccinea typica 220, 221, 223, 224, 226; coloradensis 114; crispa 222; Drummondii 219; Eatonii 118; epilobia 225; epilobioides 222; exaltata 119; filiformis 106, 118, 119; filiformis Kearneyi 119; filiformis Munzii 119, 120; filiformis typica 119, 226; filipes 107, 216, 217; filipse major 216, 217; filipes typica 216, 217, 226; fruticosa 117, 225; fruticulosa 225; glabra 224; glandulosa 112; gracilis 105, 106, 121, 122, 213, 218; gracilis glandulosa 121, 122, 218; gracilis typica 121, 226; grandiflora 108; heterandra 228; hexandra 212; hirsuta 228; hispida 219, 220; humilis 228; induta 224; laxa 228; leucocarpa 228; Lindheimeri 106, 115, 217, 226, 227; linearis 223; linifolia 228; longiflora 117; macrocarpa 106, 107, 115, 226; marginata 221; Michauxii 217; micrantha 109; mollis 107, 109; multicaulis 221; mutabilis 106, 107, 226; mutabilis glabra 108; Nealleyi 107, 121, 217, 218, 226; neomexicana 106, 113, 114; neomexicana coloradensis 114; neomexicana typica 114, 226; odorata 107, 115, 219, 226; oenotherifolia 107; parviflora 106, 108, 109; parviflora lachnocarpa 109-111; parviflora typica 109-111, 226; parviflora typica glabra 109, 110; parvifolia 223; Pitcheri 113; podocarpa 121, 122; Roemeriana 221, 222; simulans 118; sinuata 107, 218, 222, 226; spicata 222; strigillosa 121, 122; suffrutescens 222; suffulta 106, 120-122; suffulta terrellensis 120, 121; suffulta typica 120, 226; triangulata 213; tripetala 106, 211-213; tripetala Coryi 212; tripetala triangulata 212, 213; tripetala typica 212, 226; undulata 117; 228; villosa 106, 213, 214; villosa arenicola 214, 215; villosa Mc-Kelveyae 214; villosa Parksii 214, 215; villosa typica 214, 226

Gaura, Studies in Onagraceae XI. A revision of the genus 105, 211

Gauridium 105, 106, 108; Kunthii 107; molle 107; mutabile 107

Gayophytum humile 228

Gelasinospora tetrasperma 200, 258, 260

Genetic analysis of the inheritance fragrance of Gladiolus, A 181

Gibberella saubinetii 428

Ginkgo 531, 534-537, 543, 544, 547, 549-554, 556; adiantoides 89-91; biloba 90, 555, 556; laramiensis 90; pseudoadiantoides 90

Ginkgo biloba, Structure and growth of the shoot apex in 531

Gladiolus 127, 181; fragrans 182; recurvus 181-184, 187-195, 197; tristis 181-197; tristis concolor 183

Gladiolus, A genetic analysis of the inheritance fragrance of 181

GLEASON, H. A., Notes on American melastomes, including nine new species 571 Gleichenia dichotoma 313; linearis 306, 313

Globulinea giganteus 672

Gloeotrichia natans 288

Gnetum 526

Gnomonia ulmea 668

Gomerella cingulata 586

Gonglyocarpus 105; fruticulosus 225

Goniopteris 348, 351

Goplana 627

Gouania 607, 608; dominguensis 608; javanica 608; mangarevica 607, 608; Richii 608; tiliaefolia 608; vitifolia 608

Gouldia 128

Grammica 631, 642

Grand Coulee, Washington, Additional Miocene plants from 89

Greigia Berteroi 72

Grindelia 133

Grisebachiella 165

Guepinia spathularia 170

Gymnocalycium Mihanovichii 77; Mihanovichii Friedrichii 77

Gymnogramma chaerophylla 308; leptophylla 308

Gymnogramme tartarea 306, 324; tartarea aurata 324

Gymnosporangium germinale 170 Gyrocarpus 257

Habranthus 84

Halicystis 499, 590, 670

Hamamelis 520

Hapalopilus rutilans 655; subrutilans 655,

Haplophyton cimicidum 136, 144, 160 Haworthia 205, 265; reinwardtii 522

Heeria 572

Helianthus 198, 510; annuus 232, 524

Helotium 342

Hemionitis pinnata 328

Hemitelia 318; multiflora 318; subcaesia 318

Henrya 261

Hepatica fasciola 448

Herbertia Drummondii 72

Heterocentron 572-574; alata 573; axillaris 575; elegans 573; floribunda 574; glandulosa 574, 575; laxiflora 573; mexicana 574; muricata 575; occidentalis 573; rosea 573; salvadorana 575; sessilis 573; subtriplinervia 573, 574, 576; suffruticosa 573, 576; undulata 475, 576

Heterogaura 105; heterandra 228

Heteroneuron meniscioides 375

Heuchera 431; arkansana 590

Hexagona alveolaris 647; daedalea 647

Hickenia 584

Hicoria Pecan 338

Hierochloe odorata 664

Himatanthus 140

Hippeastrum Blumenavia 428

Histiopteris 318; incisa 304, 318, 327

Holopedia 383; convoluta 385; geminata 386; pulchella 385, 386, 394; sabulicola 386

Hordeum vulgare 207

Hormiscia implexa 623

Hormospora pellucida 285

Hottonia inflata 437

Hume, H. Harold, The genus Cooperia 79 Hydnum ochraceum 171; pulcherrimum 171,

173

Hydrodictyon reticulatum 443, 615

Hymenochaete Curtisii 170; epichlora 170

Hymenophyllum 318, 332, 584; ciliatum 305, 306, 318; hirsutum 318; polyanthos 329, 332

Hypholoma incertum 172

Hypocrea rufa 169; sulphurea 169

Hypolepis 319, 322; repens 305, 306, 319; viscosa 332

Hypomyces Ipomoeae 259

Hypoxylon atropunctatum 169; botrys 169; haematostromum 169; rubiginosum 169

Ilex vomitoria 486, 490 Iliamna 78

Impatiens Sultani 633

Index to American Botanical Literature 70, 123, 198, 256, 334, 421, 493, 581, 675

Inga 587

Inheritance of fragrance of gladiolus, A genetic analysis of the 181

Ionopsis utricularioides 306

Ipomoea 202

Iresine lindenii 338

Irpex cinnamomeus 171; farinaceus 174; mollis 171; Ravenelii 171

Isoetes 588; lithophila 130

Isomeris arborea 257

Isostemones 571

Italian millet, Setaria italica, Effect of artificial wind on growth and transpiration in the 229

Iva imbricata 485

Ixeris 209

Jasminum malabaricum 625, 628 Johannesbaptisia Gardneri 286; pellucida 285; primaria 285; Willei 285

Juglans egregia 90, 92; hesperia 90; oregoniana 89, 90, 92

Juncus 340; Roemerianus 664 Juniperus 401; communis 526; utahensis 410

Kalanchoe 584; rotundifolia 502

KARLING, J. S., A large species of Rhizophidium from cooked beef 439; Studies on Rhizophidium II. Rhizophidium laterale 615

KAVANAGH, FREDERICK and WILLIAM J. ROB-Kaulfussia 550 BINS, Thiamin and growth of Pythium

KECK, DAVID D., Studies in Penstemon VI. The section Aurator 233

Kniphofia uvaria 522

Labyrinthula 674 Lachnum virgineum 169 Lacmellia edulis 136, 140, 143, 156, 158, 166 Lactarius lactifluus 172; subvellereus 172

Lactuca 73, 429, 671

Laetiporus sulphureus 647

Lanopila 74

Laphophora Williamsii 432

Lapsana 343

Large species of Rhizophidium from cooked beef, A 439

LARUE, CARL D. and GEORGE S. AVERY, JR., The development of the embryo of Zizania aquatica in the seed and in artificial culture

Lastraea 314

Lathyrus 500

Laurus grandis 93, 94

Lechea 497

Leiophyllum 99, 100, 663; buxifolium 99, 101, 102; buxifolium Hugeri 101, 103; buxifolium typicum 101-103; Hugeri 99, 101, 102; Lyoni 99, 101, 102, 104

Leiophyllum, Studies in Ericales III. The genus 99

Lemaireocereus Beneckei 430

Lemna 460

Lentinus tigrinus 172

Lenzites betulina 174; saepiaria 174

Lepidium perfoliatum 672

Lepiota Morgani 172; procera 172

Leptinotarsa decemlineata 75

Leptocereus 202

Leptochilus 375; Fendleri 375

Leptochiton quitoensis 208

Leptosphaeria 260

Leskea 665

Lespedeza repens 169, 170

Liabum ovatum 131

Libocedrus decurrens 208, 518

Lilaea subulata 425

Lilium 500, 511, 526; longiflorum 583; tigrinum

199, 258

Liloeopsis 591

Linanthus 340

Lindernia microcalyx 671

Lindsaea 332; montana 332

Linum Lewisii 493

Liquidambar 96; californicum 89, 91, 96; europaeum 96; pachyphyllum 96; styraciflua

Literature, Index to American Botanical 70, 123, 198, 256, 334, 421, 493, 581, 675

Lithops bella 335

Litobrochia pedata 313

Lobivia aurea 77; Backebergii 77; Cumingii 76;

grandiflora 77

Lochnera 155, 156, 161, 163; rosea 136, 138, 144, 152, 155

Lonchites repens 319

Lophotocarpus spongiosus 423, 662

LUNDELL, C. L., Studies in the American Celastraceae 1. New species of Microtropis, Wimmeria and Zinowiewia 463

Lupinus albus 130

Lychnis dioica 73, 343

Lycopersicum esculentum 336, 431, 674

Lycopodium 257, 329, 333, 537, 538, 544, 550, 552, 553; annotinum 518; cernuum 305, 306, 329; clavatum 306, 329; complanatum 306, 329, 522; dichotomum 305, 329; lucidulum 518, 521, 525; obscurum 516, 518, 525; Pittieri 333; reflexum 305, 329; taxifolium 305, 329

Lyngbya confervoides 291; gigantea 289; hahatonkensis 292; ochracea 291

Lyngbyopsis 286; Willei 286

Maba 609, 613; buxifolia 610; cupulosa 613; elliptica 611, 612; globosa 612; nandarivatensis 610; parviflora 613; rufa 613; samoensis 613; sandwicensis 609-612; savaiiensis 611; sericocarpa 613; yaouhensis 613

Macrosiphonia Brachysiphon 137, 146, 158; Macrosiphon 137, 158

Magnolia 93, 94, 495; acuminata 94, 581; californica 97; culveri 96; dayana 93; foetida 93; glauca 655; hypoleuca 96; Inglefieldi 89, 94; obovata 93, 96; spectabilis 89, 91, 93, 94

Mains, E. B., Studies in the Uredinales, the genus Chaconia 625

Malouetia guatemalensis 137, 143, 158

Malva neglecta 345

Mammillaria microhelia 77; microheliopsis 77; viridiflora 126; Zeilmanniana 77

Mandevilla 155, 156; Bridgesii 137, 138, 146, 158, 166; hirsuta 137, 140, 145, 158; illustris 137, 145, 156, 158; laxa 137, 146; splendens 145, 156, 158; subsagittata 140, 144, 158, 152, 155, 156, 166

Marasmius iocephalus 172; siccus 172

Maravalia 625, 626; albescens 627

Marchantia 202; polymorpha 437, 438

Marginaria ensifolia 324; incana 326

MARTIN, ROBERT F., Delphinium carolinianum and its allies 27

Maryland Algae, Notes on 293

Mascarenhasia elastica 137, 146, 158

MAXON, WILLIAM R. and C. V. MORTON, The

American species of Dryopteris, subgenus Meniscium 347

McLean, Forman T., A genetic analysis of the inheritance fragrance of Gladiolus 181

Medullosa Noei 74

Melampsora Humboldtiana 170; Medusae 169, 170

Melanconis 594, 673

Melastoma 573

Melilotus 345

Meniscium 347–349, 355, 359, 369, 374, 375; acrostichoides 358; affine 364; Andreanum 352; angustifolium 361; arborescens 369; chrysodioides 372; cristatum 374; dentatum 354; elongatum 357; falcatum 360; Fendleri 374; giganteum 364; guyanense 374, 375; Jurgensenii 360; Kapplerianum 369; longifolium 369, 370; macrophyllum 375; oligophyllum 375; opacum 348, 376; palustre 354; reticulatum 358, 366; rostratum 354; salicifolium 376; Salzmanni 357; Schreberi 358; serratum 354; sessilifolium 357; sorbifolium 358, 372

Meniscium, The American species of Dryopteris, subgenus 347

Mentha 201

Merismopedia 380, 383, 384, 386; chondroidea 384, 385, 394; convoluta 380, 383, 385, 386; convoluta minor 383; elegans 380; gigas 395; glauca 380; glauca fontinalis 383, 384; Marssonii 385; paludosa 383; punctata 380–385, 394; tenuissima 384, 385; thermalis 383; Trolleri 385, 394

Mertensia 78, 164; pectinata 330

Mesechites trifida 137, 145, 158, 166

Mesotaenium 74

Mettenuisa 72

Miconia 579, 580; filamentosa 579; incurva 580; Sprucei 579

Microchaete vitiensis 287

Microcystis 378-380, 382, 394; aeruginosa 288, 289, 378, 379; flos-aquae 378, 382; incerta 377, 378; marginata 378; protocystis 378; pulverea 377, 378; viridis 378

Microdictyon 348

Micromyces 126

Microporellus dealbatus 649; mutabilis 649

Microsphaera 668

Microtropis 463; Schiedeana 464; Standleyi 463, 464

Microtropis, Wimmeria and Zinowiewia, Studies in the American Celastraceae 1. New species of 463 Mimulus 424

Minnesota pond, The taxonomy of a community of blue-green algae in a 377

Miocene plants from Grand Coulee, Washington, Additional 89

Mississippi valley, Notes on fungi from the lower 167

Monadenium lugardae 589

Monascus 132

Monochaetum 577; compressum 577; Deppeanum 578; macrantherum 578; rubescens 578

Monogyna 631, 643, 644

Monostyla 443

Moore, John Adam and Robert E. Wood-SON, JR., The vascular anatomy and comparative morphology of apocynaceous flow-

MORTON, C. V. and WILLIAM R. MAXON, The American species of Dryopteris, subgenus Meniscium 347

Morus alba 427, 524, 553

Mougeotia 615, 623

Mucor Ramannianus 275, 461

Munz, Philip A., Studies in Onagraceae XI. A revision of the genus Gaura 105, 211

MURPHY, JAMES, Raymond H. Torrey 433 MURRILL, W. A., New Florida Polypores 647

Musa 521; sapientum 526

Mutisia oligodon 208

Mycena 133

Mycosphaerella fragariae 668; rosicola 663

Myriangium 499

Myrica cerifera 486, 487, 490

Myrtus lechleriana 669

Myxophyceae I-IV Notes on 285

Naias 526 Najas gracillima 259, 343 Narcissus 439, 443, 444, 448 Narda 495

Naxia tumida 497

Nectria sanguinea 169

Nephrochytrium 497 Nephrodium 348; brachyodon 315; giganteum 364; Lechleri 366; longifolium 369; macrophyllum 328, 375; molle 316; paleaceum 314; pectinatum 319; reticulatum 358; serratum 354; sorbifolium 358, 372; sorbifolium molle

angustipinnata 372; unitum 315; villosum

Nephrolepis 319, 332; acuta 319; biserrata 305 306, 319, 332; pectinata 305, 306, 319

Nerium 135, 138; Oleander 137, 145, 149, 160 Neurospora 495; tetrasperma 71, 664

New Florida Polypores 647

New green alga: Oedocladium Lewisii, A 23

New species, Notes on American melastomes, including nine 571

New species of cacti from Guatemala, Mexico and Texas 565

Nicotiana 133, 198, 200, 261, 264, 334, 423; Langsdorffii 133; rustica 633; Sanderae 133; tabacum 663

Nigroporus vinosus 649

Nitella 198, 259, 440, 443; flexilis 439, 443, 615; hyalina 429

Nodularia fusca 285 Nostoc 288; Botrydium 291; commune 291; crepitans 291; pruniforme 291; verrucosum

Notes on American melastomes, including nine new species 571

Notes on fungi from the lower Mississippi valley 167

Notes on Maryland algae 293

Notes on Myxophyceae I-IV 285

Notes on plants of the Pacific Island. 1. 607 Notholaena 319; candida 304, 320, 322;

candida lutea 320; galapagensis 304, 306, 319, 322; sulphurea 320, 322

Nummularia clypeus 169

Nyssa 564; aquatica 558, 564; crenata 564; hesperia 564; Knowltoni 564; oregonensis

Obelidium mucronatum 343

Ochna serrulata 260

Odontadenia 146, 156; Hoffmannseggiana 137, 146, 156, 158; Schippii 137, 142, 146, 158

Odontia 172; Archeri 170; barba-Jovis 171; brunnescens 171, 173; ciliolata 171; farinacea 171; fimbriata 171, 172; macrodon

Oedocladium 24-26; Hazenii 23; Lewisii 23, 171; setigera 171 344; protonema 23, 26; Wettsteinii 26

Oedocladium Lewisii, A new green alga 23

Oedogonium 24, 26, 443, 450, 616

Oenothera anomala 107; Heribaudi 107 Lamarckiana late 199; parviflora 112; pollicata 71; organensis 495; rosea 225

Oleandra 332; articulata 332

Olfersia Langsdorfi 318

Olivea 627

Omphalia 662; campanells 172

Onagraceae XI. A revision of the genus Gaura, Studies in 105, 211 (concluded)

Ophioglossum petiolatum 494

Opuntia 260, 265, 336, 341, 400, 404, 511, 595; acanthocarpa 400, 408; aurea 401; basilaris 401, 404; Bigelovii 401, 404, 427; brachyclada 401; chlorotica 402; echinocarpa 400, 402; erinacea 404; fragilis 400, 402, 410; imbricata 507, 518, 525; phaeacantha 401, 410; polyacantha 398, 399, 401, 402, 404, 410; Ramosissima 400; rhodantha 402, 404; rubrifolia 401; stenochila 404; tenuispina 404; Whipplei 400; Wrightiana 70; xanthostemma 404

Oscillatoria 388, 390; amethystina 390-394; amphibia 390; anguina 289; animalis 288; calida 291; chalybea 289, 390, 392, 393; flexuosa 292; fontinalis 292; formosa 390, 391; Friesii 292; fusco-purpurea 292; geminata 390; Levaittae 391-392; limosa 292, 390; maricola 286, 287; Mougeotii 390; Okeni 289, 290, 390; princeps 289; princeps maxima 390; princeps tenuior 390; splendida 289; tenuis 390; terebriformis 390; vaginata 292; violacea 391

Osmunda cervina 332 Ostrya 520, 594

Ouratea 72

OVERHOLTS, L. O., Notes on fungi from the lower Mississippi valley 167

Pachyphytum viride 134

Pacific Island. 1, Notes on some plants of the 607

Paeonia 342, 343; suffruticosa 207

Pallavincia 495; Lyellii 505

Panax 561; quinquefolium 561; trifolium 561 Pandanus 521, 526, 528; Veitchii 501

Pandorina morum 293

Panicum 78, 673

Panus angustatus 172; laevis 172, 173; rudis 172; stypticus 172

Paralyxia 203

Parasitella 461

Parmelia Cladonia 438

Parodia aureispina 430

Parosela spinosa 500

Paspalum 426

Paullinia Bernhardi 76, 672

Pavonia Julianae 76, 672

Pedilanthus 336, 507, 520

Pediocactus 398; Simpsonii 409

Pelagophycus porra 338

Pelargonium 150, 163, 641; hortorum 633, 639 Pellaea atropurpurea 320; geraniaefolia 313 Pellionia pulchra 77

Penicillium 70, 588

Peniophora carnea 170; cremea 171; gigantea 171; Roumeguerii 171

Penium 450

Penstemon 126, 202, 233, 666; albidus 233-235, 237; auriberbis 234, 245, 237, 238; auricomus 252; calcareus 236, 245, 247; Cleburnei 236, 249, 252, 253; Cobaea 233-236; Cobaea purpureus 235, 236; Cobaea typicus 235, 236; cristatus 250; dayanus 254; desertorum 246; divergens 245; dolius 235, 243, 245, 249; eriantherus 234-236, 249-253; eriantherus argillosus 254; eriantherus grandis 251; eriantherus redactus 252; eriantherus saliens 250; eriantherus Whitedii 253; Gormanii 236, 249; Grahamii 236, 248, 249; guadalupensis 233-235, 237; guadalupensis Ernesti 235, 237; guadalupensis typicus 235, 237; Hansonii 236; Helleri 237; isophyllus 132; Jamesii 234, 235, 238, 252; Jamesii breviculus 239, 241, 242; Jamesii ophianthus 239, 240, 242; Jamesii typicus 239, 242; miser 236, 247, 249; Moffatii 235, 242, 249; Moffatii Marcusii 242, 243; Moffatii Paysonii 242, 243; Moffatii typicus 242, 243; monoensis 236, 245, 247; ophianthus 240-242; parviflorus 235, 238, 239; Paysonii 243; pilosigulatus 240; pseudohumilis 243; pumilus 235, 244, 245; teretiflorus 237; triflorus 233-236; triflorus integrifolius 235, 237; triflorus typicus 235, 236; saliens 250, 252; similis 239; viscidulus 237; Whitedii 236, 252, 253; Whitedii dayanus 253-255; Whitedii tristis 245, 253-255; Whitedii typicus 253, 255

Penstemon VI. The section Aurator, Studies in 233

Peperomia 597

Perezia Pringlei 125

Periploca graeca 142

Peronospora destructor 667

Pestalotia macrotrichia 71

Petitia 264

Petrea 499

Pezicula 132

Peziza pustulata 259

Phacelia 262; crenulata 76

Phacus pleuronectes 443

Phakopsora Crotonis 170

687

Phaseolus 6, 7; vulgaris 5, 6, 345, 428

Phaseolus vulgaris, Starch formation in the leucoplasts of 1

Phegopteris 348; Andreana 352; angustifolia 361; arborescens 369; falcata 360; gigantea 364, 365; macrophylla 375; membranacea 365, 366; mollis 372; palustris 354; reticulata 358; serrata 354; sorbifolia 358

Phellosperma tetrancistra 404, 409

Philadelphus microphyllus 182

Phlebia 172

Phlox bifida glandifera 207; nivalis 431; ovata

Phlyctidium 451, 615, 620; Haynaldii 623, 624 Phlyctochytrium 444, 451; bisporum 442, 445, 448, 450, 451

Phoenix 334

Phoma Puttemansii 124

Phomopsis 335

Phoradendron macrophyllum 626

Phormidium autumnale 292; Chungii 289; favosum 292; inundatum 291, 292; laminosum 289; mucicola 288, 289; penicillatum 286, 287; purpurascens elegans 291, 292; Retzii 292; Setchellianum 292; Treleasei 291; uncinatum 292

Phycastrum 450

Phycomyces 206, 268, 269, 272, 459, 461; Blakesleeanus 267-269, 273-275, 458, 459

Phyllachora graminis 169 Phyllostachys aurea 426; edulis 597; sulphurea viridis 597

Phyllosticta acericola 169; Labruscae 169

Phymatotrichum 75, 503, 671; omnivorum 201, 592; silvicolum 429

Physalospora obtusa 128

Physcomitrium pygmaeum 495

Physorhizophidium pachydermum 617

Phytolacca decandra 263

Phytomonas lactucae-scariolae 75; pruni 75; stewarti 344, 501

Phytomorula 126

Phytophthora 75, 199, 257, 268, 270–273, 275, 429, 461, 668; Boehmeriae 268–270, 272, 275; cactorum 268, 269, 272-275, 432, 663; cambivora 268, 272, 275; capsici 268, 271, 272, 275; cinnamomi 268-275; citrophthora 268-270, 272, 275, 432; cryptogea 268, 272, 275, 593; Drechsleri 268, 272, 275; fagopyri 268, 270-275; infestans 591; palmivora 268, 269, 272, 275; parasitica 268, 270, 272, 275

Phytophthora, Thiamin and growth of species of 257

Picea 537, 552, 553; abies 520; excelsa 556; mariana 586

Pinckneya pubens 672

Pinus 201, 512, 537, 552, 553, 555, 558; austriaca nigra 615; banksiana 615, 668; caribaea 516, 520, 525; coulteri 520; densiflora 615; glabra 520; Knowltoni 558; montana 556; monticola 204, 499; nigra 520; ponderosa 505; rigida 335; sabiniana 520; Strobus 496, 525; sylvestris 344, 615; taeda 170, 174, 486, 490, 520; Thunberghii 615; torreyana 520; virginiana 520

Pisum sativum 74, 259, 443, 663

Pitahaya 595

Pithecolobium divaricatum 625, 628; glomeratum 625, 628; Peckii 625; Recordii 625, 628 Pithophora 439, 443

Pityrogramma 322; calomelanos 305, 306, 322; Presliana aurata 324

Pianera 520

Plantago 591; pachyphylla 591

Plants of the Pacific Island. 1, Notes on 607 Plectocolea 495

Pleiocarpa 136, 152, 154, 155, 160, 163; bicarpellata 136, 145, 152 155, 160; mutica 136, 138, 145, 152, 154, 155, 161, 163

Pleiochloris 297

Plenckia 589

Pleopeltis aurea 324; lepidota 324; macrocarpa

Pleurotus 173; corticatus 172; ostreatus 172 Plumeria 140; rubra 136, 145, 160, 166

Plumeriopsis Abhouai 136, 145, 158 Poa annua 11, 21; Chaixii 339

Poecilopteris meniscioides 375

Pogonatum 70

Pogotrichum filiforme 342

Polemoniella 673

Polemonium 673

Polybotrya 332; cervina 332

Polypodium 324, 332; angustifolium 305, 324; astrolepis 332; aureum 305, 324; Berteroanum 317; crassifolium 305, 324, 325; Fraseri 326; Hostmanni 369; incanum 325; lanceolatum 305, 306, 324; latum 332; lepidopteris 306, 320, 325; leucosticton 326; loriceum 304, 325; meniscioides 348; paleaceum 314; paradiseae 325; pectinatum 305, 325; percussum 304, 325; Phyllitidis 305, 306, 324, 325; pleiosorum 304, 316; polypodioides 305, 325; reticulatum 347, 348, 358; rude 317; squamatum 304, 326; steirolepis 322, 325, 326; thyssanolepis 325; tridens 304, 306, 326

Polypores, New Florida 647

Polyporus abietinus 174; adustus 174; albiceps 655; amygdalinus 647; anceps 174; arcularius 174, 647; Arnoldae 653; avellaneialbus 661; badius 649; betulinus 424; biformis 174; cinnabarinus 174; cristatus 174; croceus 649; Curtisii 174; cuticularis 174, 176; dichrous 174; distortus 174, 179; dryadeus 168; dryophilus 168, 174; fimbriatus 174, 175; fissilis 168, 174, 176, 178; iocicolus 174; frondosus 174; galactinus 174; giganteus 174; gilvus 174; hirsutus 174; hispidus 168, 174, 178, 428; Humeanus 661; hydnoides 174; lucidus 168, 175, 176; ludovicianus 168, 175, 176; maximus 175; mutabilis 175, 649; nidulans 175; obtusus 175; palustris 168, 175; pargamenus 175; persicinus 175, 179; pinsitus 175; polyporus 647; porrectus 175; radiatus 179; radiatus Cephalanthi 175, 179; rhipidium 175; Rhoadsii 653, 654; rigidus 168; robiniophilus 175; sanguineus 175; Schweinitzii 175, 597; sector 175; semipileatus 175; Spraguei 175; subabortivus 661; subcubensis 661; subectypus 175; submurinus 175; subrutilans 661; sulphureus 168, 176; sulphureus cincinnatus 175, 179; supinus 175; tenuis 175; Tisdaleanus 661; versatilis 175; versicolor 175; vinosus 175; virgatus 653; Westii 650-652; zonalis 168, 175, 178

Polystichum 327; aculeatum 327; adiantiforme 305, 306, 327; apiifolium 313; coriaceum 327; pycnolepis 327

Polystictus subabietinus 661; sublimitatus 661; tenuis 175; tenuispinifer 661; versicolor 424

Polytrichadelphus Lyallii 499

Polytrichum 70

Populus 206, 513, 526, 667; balsamifera 507, 513, 516; deltoides 169, 170, 174; heterophylla 662

Poria alachuana 659; albocincta 175; ambigua 175, 180; attenuata 648; candidissima 175; eupora 175, 648; ferruginicincta 660; ferruginosa 175; flaccida 175, 180; Floridae 659; holoseparans 660; inermis 175; lacteimicans 660; laevigata 174; Langloisiana 175; Langloisii 175; medullapanis 175; nigrescens 175; punctata 175;

punctatiformis 661; undata 168, 175; versipora 175; vincta 648.

Porphyridium 387

Porphyrosiphon Notarisii 291

Portulaca 585

Potamogeton 280, 283; crispus 277, 282, 283

Potentilla tridentata 437, 438, 666

Prenanthes 671

Prestonia 150; acutifolia 137, 145, 158, 166; portobellensis 137, 138, 145, 149, 151, 158

Prosopis 583

Prosthecium 673

Protodontia 77

Psaronius 128

Pseudoagloë 296

Pseudoeugenia 264

Pseudoleskea 665

Pseudotsuga taxifolia 78, 505, 513

Pseudovalsa 673

Psilophytales from the Hamilton group in western New York, Some 599

Psilotum 330; nudum 305, 306, 330; triquetrum 330, 556

Psoralea psoralioides 260

Ptelea 132, 561; enervosa 560, 562; miocenica 560; mollis cryptoneura 560, 562

Pteridium 327; aquilina esculenta 327; arachnoideum 306, 318, 327

Pteridophyta of the Galapagos and Cocos Islands 303

Pteris 327, 550; aculeata 327; angustifolia 309; apicalis 327; aurantiaca 320; biaurita 305, 306, 318, 327; incisa 318; lutea 320; pedata 313; propinqua 327; propinqua Cumingiana 304, 327; quadriaurita 305, 306, 327; sulfurea 320

Pterogyne nitens 426

Puccinia graminis avenae 339, 666; graminis Tritici 339; Hydrocotyles 170; iridis 340; Parkerae 502; Polygoni-amphibii 170; Smilacis 170; Xanthii 170

Pycnoporus sanguineus 647

Pyramidomonas 301

Pyramimonas 293; inconstans 293; montana 293, 295, 296, 300, 301; tetrarhyncus 293

Pyrolirion 84; albicans 83, 84, 87

Pyropolyporus taxodii 651, 661 Pythium 454, 456; Butleri 453-461

Pythium Butleri, Thiamin and growth of 453

Quercus 512, 524, 526; alba 560; Catesbaei 490; consimilis 92; malheurensis 560, 562; marylandica 170; Merriami 92; nigra 169,

176; Phellos 176; spokanensis 89; ursina 89, 92, 95; virginiana 486, 490 Quercus-Carya 128

Raduia 125

Radulum vinosum 171, 172

Randia 607; cochinchinensis 614; coffeoides 614; Graeffei 614; racemosa 614

Ranunculus neglectus 77

RAO, V. PANDURANGA, Effect of artificial wind on growth and transpiration in the Italian millet, Setaria italica 229; Response of sorghum to high and low soil moisture 413 Raphia 512

Rauwolfia 206; tetraphylla 136, 140, 146, 147, 158, 166

Raymond H. Torrey 433

Razumovia 264

READ, CHARLES B., Some Psilophytales from the Hamilton group in western New York

Rebutia Fiebrigii 77; Marsoneri 430; pseudodeminuta 430

Regnellidium diphyllum 497

Rehmiellopsis bohemica 594

Response of sorghum to high and low soil moisture 413

Rhabdadenia biflora 137, 144, 158

Rhamnites 97

Rhamnus 97

Rhapidophyllum Hystrix 134

Rhazya orientalis 136, 144, 160

Rhipsalis Bartlettii 567, 569

Rhizoctonia solani 424

Rhizophidium 439-442, 444-451, 615, 619, 621, 622; agile 442, 443, 448, 450, 451; carpophilum 623; gibbosum 442-444, 448, 450, 451; laterale 615, 616, 618, 620-623; macrosporum 439, 440, 442; messanense 444; rostellatum 448, 450, 451; rotellatum 450; sphaerocarpum 441, 445, 446, 621

Rhizophidium from cooked beef, A large species of 439

Rhizophidium laterale, Studies on Rhizophidium II 615

Rhizophlyctis 440

Rhododendron

Rhodotorula 461

Rhoeo 521; discolor 522, 526

Rhus 198, 493, 561; bendirei 90; diluvialis 561; glabra 130, 526; Merrilli 89; oregonensis 561, 562; Toxicodendron 170, 561; trilobata 561

Rhynchanthera 561; Hookeri 571; mexicana 571; paludicola 571

Rhytisma acerinum 169; Vaccinii 169

Ribes 204, 588; aureum 597; lacustre 499 Riccardia 495

Ricinus communis 207

ROBBINS, WILLIAM J., Thiamin and growth of species of Phytophthora 267

ROBBINS, WILLIAM J. and FREDERICK KAVA-NAGH, Thiamin and growth of Pythium Butleri 453

Rosellinia necatrix 203

Rotrychium dissectum 501

Rubus 513, 597; frondosus 507, 513

Saccoloma 333; elegans 333 Saintpaulia ionantha 341

Salpiglossis 259

Salsola collina 499

Salt spray: an important factor in costal ecology 485

Salvia 337, 526

Salvinia 594; natans 526

Sapindus oregonianus 498

Saprolegnia ferax 505

Sapromyces Reinschii 673

Saracha 590

Sceptranthes 79, 80; Drummondii 79, 82, 84 SCHAFFNER, JOHN H., Spiral systems in the

vascular plants 507

Schizocarya crispa 222; Drummondii 219; Kunthii 222; micrantha 109, 110

Schizocentron 573

Schizococcus 260

Schizophyllum commune 172

Schozopodium 600; dividi 600, 601, 606;

mummii 600-602, 606

Schizorcarya 105

Schizothrix mexicana 286; thelephoroides 288

Scirpus tuberosus 426

Sclerocactus polyancistrus 408; Whipplei 398, 408, 410

Sclerotinia 497; fruticola 586

Sclerotinosis 258

Sclerotium rolfsii 666

Scutiger persicinus 648

Scytonema atrovirens 291; guyanense 291;

Hofmannii 287 Sebacina incrustans 170

Secale cereale 127, 207

Selaginella 73, 333, 518, 526; arenicola 518, 525; horizontalis 333; kraussiana 522

Senecio bombycopholis 125; millefolium 256; moreliae 125; rugelia 256; Tabacon 428

Septobasidium 259, 425; pseudopedicellatum 170; retiforme 170

Septoria 597; lycopersici 432; Rubi pallida 169 Septotinia 78

Sequoia washingtoniana 525

Setaria italica 229-232

Setaria italica, Effect of artificial wind on growth and transpiration in the Italian millet 229

Setchelliella pilosa 287

Shoak, I. V. and B. W. Wells, Salt spray: an important factor in coastal ecology 485

Sibbaldiopsis tridentata 438

Silene menziesii 668

Silphium 205

Skierka 627

SMITH, HELEN V., Some new and interesting late tertiary plants from Sucker Creek, Idaho-Oregon boundary 557

Solanum 202; tuberosum 427, 513

Solenia candida 175

Solidago 128; rugosa 261; sempervirens 261

Some new and interesting late tertiary plants from Sucker Creek, Idaho-Oregon boundary 557

Some Psilophytales from the Hamilton group in western New York 599

Sordaria fimecola 265

Sorghum 416, 418; cernuum 413

Sorghum to high and low soil moisture, Response to 413

Spaeropsis ellisii 494

Sphaceloma 201, 497; symphoricarpi 66

Sphacelotheca cruenta 131

Sphaerocarpos 198, 340

Sphaerotheca lanestris 430

Sphenospora 627

Spiral systems in the vascular plants 507

Spiranthes gracilis 335

Spirillum Jenneri 388, 389

Spirodela polyrrhiza 432

Spirogyra 450, 615, 616, 623; crassa 443, 450,

Spirulina 388, 390, 395; aeruginea 387-390, 392-394; amethystina 388-394; densa 290; Jenneri 388; Jenneri platensis 290; major 290; platensis 289; vaginata 422

Spondylomorum quaternarium 299, 301

Sporobolus Berteroanus 169

Spruceanthus 72

Stagonospora Curtisii 202

Starch formation in the leucoplasts of Phaseolus vulgaris 1

Stauropteris 605

Stelis 662

Stemmadenia 158 162; Alfari 136, 143, 156 159; grandiflora 136, 142, 143, 159; obovata 136, 143, 159

Stemonitis 201

Stenosiphon 105; linifolium 228

Stereum fasciatum 171; frustulosum 171, 179; fuscum 171; gausapatum 171; pargamenum 171, 173, 175; rameale 171; Ravenelii 171; subpileatum 171, 179; umbrinum 171

Stigeoclonium 615, 623; tenue 615, 616

Stigmaria 510

Stigmatopteris 348, 349, 376

Strobilomyces strobilaceus 174

Strophanthus 138, 150; dichotomus 137, 145, 160; gratus 137, 145, 148, 160, 166; sarmentosus 137, 145, 149, 150, 160

Structure and growth of the shoot apex in Ginkgo Biloba 531

Studies in Ericales III. The genus Leiophyllum

Studies in Onagraceae XI. A revision of the genus Gaura 105, 211

Studies in Penstemon VI. The section Aurator

Studies in the American Celastraceae 1. New species of Microtropis, Wimmeria and Zinowiewia 463

Studies in the Uredinales, the genus Chaconia 625

Studies on Rhizophidium II. Rhizophidium laterale 615

Stylocoryne coffeoides 614; racemosa 614

Styrax 127

SVENSON, H. K., Pteridophyta of the Galapagos and Cocos Islands 303

Symphoricarpos albus 593

Symploca profunda 286

Symplococarpon Hintoni 123

Synechococcus aeruginosus 386, 387

Tabernaemontana acutissima 136, 142, 143, 159; arborea 136, 143, 159; chrysocarpa 136, 138, 140, 145 159, 166; Cumingiana 136, 144, 159; divaricata 136, 144, 159

Taenitis angustifolia 309

Taphrina caerulescens 169 Taxonomy of a community of blue-green algae in a Minnesota pond, The 377

Taxus baccata 501

Tectaria 328; martinicensis 305, 328 Tetrachondra patagonica 664 Tetramerium 261 Tetrapedia 383 Thalictrum 207 Thelypteris serrata 354 Thenardia Galeottiana 137, 138, 144, 158 Thevetia peruviana 136, 138, 140, 146, 147, 158 Thiamin and growth of Pythium Butleri 453 Thiamin and growth of species of Phytophthora 267 Thompsonella 76 Thraustotheca clavata 428 Thrinax 493 Thuja 526 Tibouchina paludicola 571 Tildenia pilosa 287 Tilia 520, 526 Tillandsia insularis 306 Tilletia levis 265, 665; Tritici 265, 665 Tingia 585 Tithymalus 336 Torrey, Raymond H. 433 Trachelospermum difforme 137, 144, 158; jasminoides 137, 144, 158 Trachomitum 149, 150, 160; venetum 137, 145, 161 Trachypteris 328; Drakeana 304; Gilliana 328; Gillianum 304; pinnata 304, 306, 328 Tradescantia 78, 207, 669; ozarkana 71; paludosa 673

Trametes amygdalina 647; cubensis 175, 657; **Humaena** 656, 661; malicola 175; rigida 175; sepium 175; **subcubensis** 656, 661; subroseus 69; versatilis 175
Trapa bicornis 668

Tremellodendron 77; pallidum 170 Tribulus 521; terrestris 526 Trichomanes 329, 333; capillaceum 333; cocos 320, 333; elegans 333; Hookeri 333; Krausii 305, 329; pusiilum 329; radicans 333

Tridens 426
Trifolium 668
Trillium 201, 262
Triodia 664
Trisetum 673
Triticum 262, 443 664; aestivum 590
Trixis decurrens 125
Tropaeolum 640; majus 639, 640
Tsuga candensis 520
Tulipa 431, 596
Tympanis 129

Tyromyces aveilaneialbus 657, 661; Spraguei 656

Ulmus 520, 526; americana 522; fulva 673
Ulothrix 615, 616, 618; zonata 615, 618, 623
Uniola paniculata 485
Urechites Andrieuxii 137, 144, 158 166
Uredinales, the genus Chaconia, Studies in the 625
Urginea maritima 583
Urnula Geaster 71
Uromyces albescens 627; Lespedezae-procumbentis 169, 170; pallescens 625; Toxicodenation 170
Ustilago avenae 77, 477, 483; Hordei 343;
Kolleri 483; levis 477, 479 481–483
Utah, The Cactaceae of southern 397
Utahia Sileri 400, 406, 409
Utricularia 283

Vaccinium 670; arboreum 169 Vagnera stellata 438 Valeriana parnassiifolia 427 Valerianella 664 Vallisneria spiralis 596 Valonia 336, 425, 502 Vascular anatomy and comparative morphology of apocynaceous flowers, The 135 Vaucheria 23, 124, 426, 450, 593 Venturia inaequalis 667 Verbena stricta albiflora 672 Vernonia fasciculata corymbosa 669 Verticillium 75 Viburnum 261; Opulus 555; rufidulum 555 Vigna sinensis 256 Vinca 161, 163; major 136, 144, 155; minor 136, 144, 155, 166 Vitis vinifera 130, 674 Vittaria 333; angustifolia 309; lineata 333 Volvaria bombycina 172, 173 Vulpia 129

Washington, Additional Miocene plants from Grand Coulee 89 Wedelia glauca 128 Weichselia 257 Wells, B. W. and I. V. Shunk, Salt spray: an important factor in coastal ecology 485 Whitford, L. A., A new green alga; Oedocladium Lewisii 23 Wimmeria 463; acapulcensis 465-467; Bartlettii 467, 469; concolor 469; confusa 467, 468; lanceolata 467; pallida 467; persicifolia 467

Wimmeria and Zinowiewia, Studies in the American Celastraceae 1. New species of Microtropis, 463

Winter buds of Brasenia, The 277

Wolffiella floridana 355; oblonga 128

Woodson, Jr., Robert E. and John Adam Moore, The vascular anatomy and comparative morphology of apocynaceous flowers 135

Woodwardia 557; crenata 557; deflexipinna 557, 558; Maxoni 557; virginica 557, 558

Xanthoxylon 329

Young, Pauline, Starch formation in the leucoplasts of Phaseolus vulgaris 1 Youngia 123

Yucca 518, 526; Howard-Smithii 593; rupicola 594 Zamia 516; floridana 520; furfuracea 520; integrifolia 516, 518, 520, 525

Zea mays 11, 124, 131, 259, 260, 443, 500, 522, 524, 525

Zephyranthes 79, 84-86; albicans 83, 84, 86; Drummondii 79, 84, 86; macrosiphon 86

Zinowiewia 463; australis 469, 470; concinna 470, 471; costaricensis 471, 472; integerrima 471, 475; Matudai 472, 476; pallida 473-475; rubra 473, 475, 476

Zinowiewia, Studies in the American Celastraceae 1. New species of Microtropis, Wimmeria and 463

Zizania 11, 14, 17; aquatica 13-20, 339

Zizania aquatica in the seed and in artificial culture, The development of the embryo of 11

Zschokkea panamensis 136, 146, 158, 166; ramosissima 136, 146, 158

Zygadenus fontanus 127

Zygocactus truncatus 526

TORREY BOTANICAL CLUB

OFFERS TO BOTANICAL LIBRARIES AND OTHERS wishing to keep in touch with the rapidly growing American botanical literature

A CARD INDEX

of all botanical publications of the New World from 1893 to 1937. Each title is printed on a separate card in two sizes, 2" x 5" and 3" x 5", in library style, and is available at 3 cents each.

The cards are sold in sets covering any year in this period. Subscriptions for 1938 are open. The approximate number of cards for 1938 will be 1600. The estimated cost of the cards for this year will be \$48.

Address all inquiries to

Dr. HAROLD N. MOLDENKE, Treasurer Torrey Botanical Club, New York Botanical Garden Fordham Station, Bronx Park, New York City

MADE IN U.S.A.

The Standard for Microscope Glass

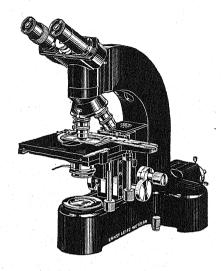
Gold Seal Microscope Slides and Cover Glasses

Crystal Clear · Non-Corrosive · Will Not Fog

Microscopic work demands glass of unusual clarity. Gold Seal Slides and Cover Glasses are made from glass practically free from alkali. They attain a precise and uniform thinness of plane surface. Therefore, Gold Seal offers an unusual degree of crystal clarity. Further, Gold Seal is guaranteed against corrosion, fogging or any imperfection. Specify Gold Seal Slides and Cover Glasses.



"ORTHOLUX" BY Leitz



Ultra modern design featuring: Permanently aligned, built-in light source. Transmitted and incident illumination. Binocular and monocular vision.

Microscope "ORTHOLUX" is the product of years of intensive research in advancing the design of microscopes in the interest of the user by the world's largest manufacturer of microscope equipment.

Never before has a microscope of this type incorporated so many features of outstanding importance: the base and arm are one piece. The observation tubes—monocular or binocular—are interchangeable. The source of light, suited for visual observation and photomicrography, is built-in and permanently aligned. Ball-bearing coarse and fine adjustments are located at the base for convenience. The new mechanical stage takes slides up to two by four inches.

E. LEITZ, INC. 730 FIFTH AVENUE, NEW YORK, N. Y. WASHINGTON CHICAGO DETROIT

(Makers of the famous LEICA Cameras) Western Agents: Spindler and Sauppe, Inc., Los Angeles · San Francisco

Aristolochia Stem

The stem of Aristolochia has long been a favorite object for the study of the vine type of structure in a dicot. Already listed in our catalog are cross sections of very young stem for procambium (B7.3141), intermediate age of stem for protoxylem, protophloem and procambium (B7.3142) and old stem showing annual rings and anomalous structure (B7.3143). We now wish to announce the addition of a long section of older stem (B7.3144, \$0.60) and a composite slide bearing young stem and cross and long sections of older stem (B7.3145, \$1.00).

GENERAL BIOLOGICAL SUPPLY HOUSE



Incorporated

761-763 EAST SIXTY-NINTH PLACE CHICAGO

The Sign of the Turtox Pledges Absolute Satisfaction

